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The adoption of Open Innovation in the Smart Building industry: an empirical analysis.

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A Mamma e Papà.

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Executive Summary

The adoption of the Open Innovation paradigm has enormously increased in the last decade. Authors and practitioners have deeply described its benefits and how it would improve firms' performances. Open Innovation is the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively. This new method of doing business has taken place always more in the last years and it's now the gold standard for most companies, in both its two connotations, Inbound and Outbound. Literature analyzes deeply the OI paradigm and its bonding to industry convergence but lacks a clear definition and taxonomy of its adoption inside a new converging industry, the Smart Building industry.

Smart Buildings industry has made its appearance in the everyday discussions' topic due to its innovativeness, particularity and huge possibilities that offers. Smart Buildings are digitally connected structures that combine optimized building and operational automation with intelligent space management to enhance the user experience, increase productivity, reduce costs, and mitigate physical and cybersecurity risks. Within Smart Buildings, people can meet and interact with each other, exploit advanced technology to perform their functions, and benefit from a digitally enhanced experience overall.

This thesis aims at exploring the sectorial application and embracement of Open Innovation in the Smart Buildings industry, opening a new field of research and increasing the understanding of how firms behave in the Smart Building world. Specifically, the study is focused on the partnerships that are undertook by the different companies performing in the industry, their moving reasons and the similarities and patterns that have been recognize all across the different firms.

The analysis has been held though the support of a database that gathered the willingness of managers belonging to 51 different firms currently performing in the Italian Smart Buildings industry. The methodology adopted is the multiple case study methodology, since it enables to let the theory emerge from case studies, meaning that the relationships' patterns recognized within the case and between cases help creating a theory that provides a general interpretation of the phenomenon. Firstly, the interviewed companies have been gathered into clusters on the basis of the products or services offered on the market. Then, for each cluster, have been listed and analyzed all the partnerships that the players undertook and the moving reasons, namely the knowledge or competences needed, have been showed. Founding that firms crave mainly complementary

knowledge and resources; the convergence of the industry makes fundamental the access to complementary knowledge since the competences belonging to just one traditional sector aren't enough anymore. And commercial and operational knowledge, fundamental to access and address effectively the market.

Then, a comparative analysis has been held. To avoid the restriction of the clusters and have a more general understanding of the behaviors of these firms in the market. Grouping and listing all the partnership found by the analysis showing then the main trend in the market. Presenting three notable case studies to strengthen the findings of the analysis and give a better and deeper understanding of what Smart Buildings are and how companies partner up to perform in this converged industry.

The last part of the analysis is focused on findings behavioral patterns that are cross industry and elude from the constrain bought by the clusterization. To do so all the partnerships found has been analyzed under five different variables: knowledge/competences acquired, company dimensions, customers' sector, partnership' purpose, number of partners. The results are the identification of five different behavioral patterns that describe five different behaviors of firms in the industry, that don't depend on the belonging industry but, mainly, on the companies' aim in the market and the needed complementary competences.

As any research this study presents limitations that open many roads to future possible developments. The main limitations regard the data source, their quality and the dimensions of the studied set. A more numerous datasets will provide a higher and more specific level of detail and could improve the obtained results and strengthen the results of the analysis. Moreover, the data that were gathered aren't equally distributed in all the clusters, a more equally distributed set would provide more balanced data and would make easier the identification of behaviors and partnerships types that this research has not considered for lack of data.
Lastly the data were gathered only in the Italian market and only for projects held in Italy. This focus only on the Italian market does not assure results generalizability in all the other countries.

This thesis wants to raise awareness of how deeply the Open Innovation method is adopted in the Smart Building industry and, in particular, of which are the companies' typologies and clusters that tend to alliance most and the main pushing reasons that stand behind these. But, more interesting, are the patterns found in the second part of the analysis. These in fact show how alliances are not

cluster specific but eludes from these and industry belongings, and depends solely on the firms' aims, needed competences and customers, and indirectly by their dimensions.

Executive Summary ITA

L'adozione del paradigma Open Innovation è aumentato enormemente nella scorsa decade. Autori e professionisti hanno profondamente descritto i suoi benefici e come possa migliorare le performance delle aziende. Open Innovation è lo sfruttamento di flussi di conoscenza, da fuori a dentro e da dentro a fuori, per accelerare il processo di innovazione, ed espandere i mercati in cui sfruttare le innovazioni, rispettivamente. Questo nuovo metodo di fare business ha sempre più preso piede negli anni passati ed è adesso il gold standard per la maggior parte delle compagnie, in entrambe le sue connotazioni, Inbound e Outbound. La letteratura analizza in profondità il paradigma Open Innovation e i suoi legami con la convergenza di una industria ma manca di una chiara definizione e una classificazione della sua adozione all'interno di una nuova industria convergente, l'industria degli Smart Buildings.

L'industria degli Smart Buildings è sulla bocca di tutti a cause della sua innovatività, particolarità e a cause delle grandi opportunità che offre. Gli Smart Building sono strutture connesse digitalmente che combinano l'ottimizzazione dell'edificio e l'automazione operazionale con la gestione intelligente dello spazio per esaltare l'esperienza degli utenti, aumentare la produttività, ridurre i costi, e mitigare i rischi fisici e di cyber sicurezza. All'interno degli Smart Buildings, le persone possono incontrarsi e interagire tra di loro, sfruttando tecnologie avanzate per eseguire le loro attività, e beneficiare di una esperienza complessiva digitalmente potenziata.

Lo scopo di questa tesi è esplorare l'applicazione settoriale e l'adozione dell'Open Innovation nell'industria degli Smart Buildings, aprendo un nuovo settore di ricerca e aumentando la comprensione di come le aziende si comportano nel mondo degli Smart Buildings. In particolare, questa ricercar è focalizzata sulle partnerships che vengono create dalle diverse compagnie operanti nell'industria, le loro motivazioni, le somiglianze e gli andamenti che sono stati identificati attraverso compagnie differenti.

L'analisi è stata effettuata attraverso il supporto di un database che ha raggruppato la testimonianza di managers appartenenti a 51 aziende diverse che stanno attualmente operando nel mercato italiano degli Smart Buildings. La metodologia che è stata adottata è la metodologia dei case study multipli, poiché questa fa sì che la teoria emerga dai case studies, stando a significare che gli andamenti delle partnerships identificati all'interno dei casi e attraverso casi diversi aiuta a creare

una teoria che dà una interpretazione generale del fenomeno. Per prima cosa, le compagnie intervistate sono state raggruppate in gruppi sulle basi dei prodotti o servizi che offrono sul mercato. Poi, per ogni gruppo, sono state listate e analizzate tutte le partnerships che i player hanno sottoscritto e le motivazioni dietro a queste, ovvero la conoscenza o le competenze di cui avevano bisogno, sono state mostrate. Trovando che le aziende hanno bisogno principalmente di conoscenza e risorse complementari; la convergenza del mercato rende infatti fondamentale l'accesso a conoscenza complementare poiché le competenze appartenenti a solo un settore tradizionale non sono più abbastanza. E la conoscenza commerciale e operazionale, fondamentale per accedere e arrivare efficacemente sul mercato.

Poi, è stata fatta una analisi comparativa. Per evitare la restrizione dei gruppi e avere una idea più generale del comportamento delle aziende nel mercato. Raggruppando e facendo una lista delle partnerships trovate nell'analisi e mostrando i trend principali nel mercato. Presentando tre case studies degni di nota per rafforzare i risultati delle analisi e dare una idea migliore e più approfondita di cosa sono gli Smart Buildigns e come le aziende creano partnership per essere performanti in questo mercato converso.

L'ultima parte della analisi è focalizzata nel trovare degli stili comportamentali che attraversano l'industria ed eludono le costrizioni portate dalla creazione dei gruppi. Per fare questo tutte le partnerships trovate sono state analizzate attraverso cinque variabili diverse: conoscenza/competenze acquisite, dimensione delle aziende, settore dei clienti, obiettivo delle partnerships, numero dei players. I risultati sono l'identificazione di cinque tendenze comportamentali diverse che descrivono cinque comportamenti differenti delle compagnie nella industria, che non dipendono dalla industria di appartenenza, ma solo dalle mire delle aziende nel mercato e dalle competenze complementari di cui hanno bisogno.

Come qualsiasi ricerca questa presenta limitazioni che aprono molti sbocchi futuri. Le maggiori limitazioni riguardano la fonte dei dati, la loro qualità e le dimensioni del set di dati studiato. Un database più numeroso darà un maggiore e più specifico livello di dettaglio e può migliorare i risultati ottenuti e rafforzare i risultati delle analisi. In più, i dati che sono stati raccolti non erano equamente distribuiti in tutti i gruppi, un campione meglio distribuito potrebbe dare dati più bilanciati e potrebbe rendere più facile l'identificazione di comportamenti e tipi di partnerships che questa ricerca non ha potuto considerare per assenza di dati. Inoltre, i dati sono stati raccolti solo

per il mercato italiano e solo per progetti realizzati in Italia. Questo focus solo sul mercato italiano non assicura risultati generalizzabili in tutti gli altri stati.

Questa tesi vuole aumentare la conoscenza di come profondamente la Open Innovation è adottata nella industria degli Smart Buildings e, in particolare, quali sono le tipologie e gruppi di aziende che tendono ad allearsi di più e le maggiori ragioni che spingono e stanno dietro queste partnerships. Ma, più interessante, sono le tendenze trovate nella seconda parte delle analisi. Queste infatti mostrano come le alleanze non sono specifiche di un gruppo ma eludono da questi e dalle industrie di appartenenza, e dipendono solo dalle ambizioni delle aziende, dalle competenze di cui necessitano, dai clienti, e, indirettamente, dalle loro dimensioni.

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CHAPTER 1: INTRODUCTION

1.1. Introduction

Open Innovation is the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively. This new method of doing business has taken place always more in the last years and it's now the gold standard for most companies, in both its two connotations, Inbound and Outbound. Due to the diffusion of innovation intermediaries, the always tighter intellectual property regime, the growing mobility of technical and knowledge professionals, the birth and expansion of the market for technologies, and the always more complex and expensive technologies, the firms were forced to abandon the old concept of the company as an island, that develops, produces and sells all by itself. In favor of a new, more dynamic idea of the company as part of an innovative environment where most of the opportunities reside outside the firm itself and the only way to grasp those is opening up. An example of Open Innovation is Lego Ideas; a platform where everyone can submit designs for new Lego products and receive votes from the community, the most voted designs will then be evaluated by a specialized Lego's team and if approved will be produced and commercialized. This is a great example of involving the crowd in the new product development and resides on the concept that the best ideas most of the times are outside the company.

The adoption of the Open Innovation paradigm has increased in the last decade. Authors and practitioners have deeply described its benefits and how it would improve firms' performances. Over the past few years, many companies encouraged their employees to be more active "open innovators" and to interact with external parties to find new ideas and increase their knowledge to improve existing products, processes, and services, or to create new ones. (Salter A., Criscuolo P., Ter Wal A.L.J., 2014)

The spread of the Open Innovation paradigm has clearly been explained and demonstrated by Cricelli, Greco and Grimaldi in their paper "*Assessing the Open Innovation trends by means of the Eurostat Community Innovation Survey*". The authors in their research analyzed first the reasons

behind the spread of Open Innovation and then verified and demonstrated that the spread of it is real and not only theoretical.
Regarding the reasons that stand behind the expansion of Open Innovation four big reasons have been identified.

- The Open Innovation paradigm has been theorized consequently to the observation of a change by the leading innovative firms in their approach to innovation, opening it. So, following the leader-follower logic, is very likely that the follower firms followed the example of leading innovators, also in the light of the positive effect on performance that the literature promoted and showed.
- Numerous authors explicitly recommended the adoption of the Open Innovation paradigm to managers. Since many journals explicitly aimed at providing to companies practical suggestions and steps to follow in the road to Open Innovation, it may be argued that such suggestions have been followed by a growing number of managers. Increasing always more the number of firms adopting the Open Innovation paradigm.
- The exponentially increasing number of articles, dedicated conferences and seminaries and journals studying Open Innovation can have encouraged the interest in the topic.
- The creation of local, national and international programs aimed at encouraging the interaction among different organizations, such as the "Open Innovation Network", or the "Startup Europe Partnerships", later recalled, supported both by the European Commission, has been a determinant of an actual increase in firms' interest and adoption of the Open Innovation paradigm.

The results of Cricelli, Greco and Grimaldi's research confirm that the share of firms adopting the Open Innovation paradigm has increased. Their findings demonstrate that firms are actually increasingly opening up always more, but do not explore which sources of innovation or which approaches to Open Innovation are more likely to improve the innovation performance. The percentage of adoption of Inbound Open Innovation, in particular, among firms is actually very high, around 90% of the considered firms. The authors also revealed how firms seem to appreciate exploring different sources of knowledge than focusing on just some of them. Meaning that firms, usually resort to different sources with, apparently, a medium-low degree of intensity, and interact intensely only with few players. (Cricelli, Greco, Grimaldi, 2016)

Introduction

This trend of opening boundaries of firms to external partners has been registered always more also by practitioners. The consulting company PricewaterhouseCoopers, Pwc, for example conducted a major global study, *"Pwc's Innovation Benchmark",* surveying over 1,200 executives in 44 countries speaking in depth with individuals charged with managing innovation initiatives at leading companies. Their goal was to understand how these leaders view innovation and what they are doing to better reap its rewards, innovation has been considered across a various set of challenges, including innovation strategy, operating models, culture, metrics, and more to understand how innovating companies are seeking to create business value and financial returns on their efforts. One of the results of the research, among others, was that companies are opening up the innovation process earlier to a broader set of stakeholders both inside and outside the company.

Innovative companies aren't innovating alone, instead, they're opening up the boundaries of innovation both inside and outside their organizations creating a much wider ecosystem for ideas, insights, talent, and technologies, taking onboard the customer throughout the innovation process. Traditional R&D development is always more abandoned in favor of more inclusive innovative models, such as Open Innovation, Design Thinking, and co-creation with partners, customers, and suppliers. In particular Open Innovation has been adopted by the 61% of all the interview firms and co-creating with customers, partners, suppliers, a branch of the wider Open Innovation paradigm, by the 55%. This last type of collaboration is considered the most important innovation partnership by over one-third of companies, the 35%. PwC also registered that the majority of firms resorting to customer engagement strategically helped them in defining innovation requirements from the early ideation phase. The majority of respondents, in fact, say they are bringing customers into the innovation process at the ideation phase.

It's a far cry from the days when innovation was viewed as a functional capability existing only inside isolated R&D centers. Instead, Pwc's benchmark showed how companies are focused on creating winning innovation cultures, and in bringing in new ways of thinking and ideas from both inside and outside corporate boundaries. Indeed, inclusive innovation operating models, such Open Innovation and co-creation with customers, partners, and suppliers, now are all far more prevalent than traditional R&D. And these new innovation approaches are delivering results. (Key insights from PwC's Innovation Benchmark)

Others evidences of this spread of the Open Innovation paradigm are the creation of programs and organizations that favor the collaboration and the exchange of information between companies. In particular, at the European level, the Startup Europe Partnership (SEP) has been created. Established by the European Commission in 2014 is the first pan-European Open Innovation platform dedicated to transforming European startups into scaleups by linking them with global corporations and stock exchanges. By participating in the SEP program, global companies have access to the best technologies and companies with the goal of initiating business partnerships and venture corporate investments. *"Collaboration between established corporates and startups can bring tremendous benefits to both. Startups get the possibility to access resources and market insight to help them scale up, whilst, for established companies, such collaborations can be a strong driver of innovation - as well as bring subtler benefits like cultural change. However, it is hard to get it right. We believe that the organizations doing this well should be recognized as trailblazers and hope that they inspire others*". Jyrki Katainen, European Commission Vice President for Jobs, Growth, Investment and Competitiveness.

In the report "*the status of Open Innovation in Europe, corporate-startup collaboration*" by SEP, among other things, is underlined how one noticeable trend over recent years has been an increasing move towards Open Innovation and, in particular, collaboration with startups. Moreover, the report stated how the 88% of the surveyed companies have a dedicated Open Innovation unit and how the whole majority of firms resort to more than one Open Innovation models.

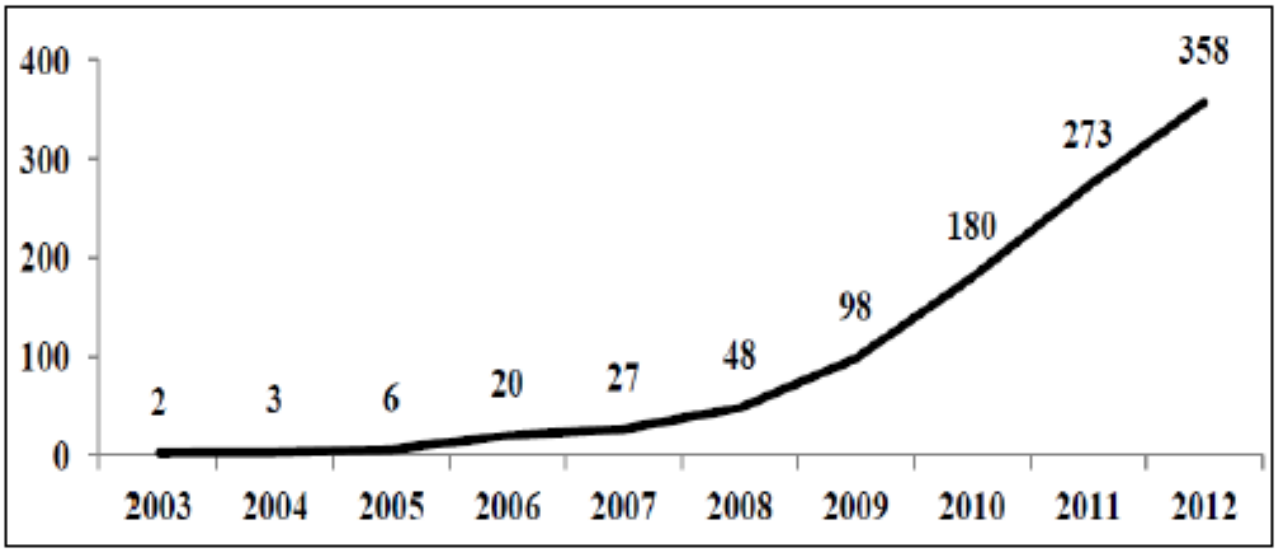

Table 1:Annual trend of scientific publications in the Thomson Reuters Web of Science Database containing the worlds "open innovation" in the title, abstract or keywords (source: Kovacs, Van Looy, Cassiman, 2015)

Introduction

The Open Innovation concept has been deeply studied by numerous scholars in almost all its parts, evidenced by the number of publications on the subject that has increased tenfold in a few years, as can be seen in the TABLE 1, but literature doesn't cover all the sectoral application of this paradigm, there are some dark spots that haven't been considered yet. In particular is lacking a research that studies and shows the application of Open Innovation in the new, emerging Smart Building industry.

The Smart Building industry is a very promising and interesting industry under this light. This, on one side, for the always increasing interest and understanding of the topic in the last years and, on the other for the nature of the Smart Building industry itself.
Regarding the becoming of Smart Building a trend topic; broad public support and government incentives are pushing the adoption of these IoT based Smart Buildings for new sustainable construction, these are important because are a signal of the dynamic approach to sustainability in the construction sector. The always more pressing environmental issues create both opportunities and new constrains, Smart Buildings are the answer to both of them reducing costs simply by consuming energy more responsibly and in a more planned and controlled manner (Why are Smart Buildings important?). Moreover, these allow organizations, since Smart Buildings have a B2B approach, to manage physical assets in a more cost-effective way and will contribute to the reduction of carbon emissions. Viewed as an overall, the Smart Building is what people want and society needs. It solves its own problems and it enhances the experience of its occupiers.

Property investors are very much attracted by Smart Buildings, since these can bring value to customers, distinguish from competitors and generate revenues. In particular the Global Real Estate Sustainability Benchmark forecasts for each building:

- 2 – 17 % increase in resale value.
- 9 – 18 % higher occupancy rates.
- 8 – 35 % increased rental rates.
- 30% lower operating expenses.
- 9% higher net operating income.

Smart Buildings' market is an accelerating trend all across the globe, in 2015 the global market accounted for 6.4 billion $ in revenues and is expected to grow at a compound annual growth rate (CAGR) of 32%, reaching 43 billion $ by 2022 (Smart Building Market 2018 Global Trends, Market

Share, Industry Size, Growth, Opportunities and Forecast to 2023), with a forecasted increase of number of units from current 233 to over 980 million units (of both Smart Buildings and Smart Homes). The European region is lagging behind but is forecasted that will reach the 24% of the global market share by 2025, while the American will account for the 40% and the APAC region for the 33%. (Smart Building: Energy efficiency application, 2017)

Smart Buildings' industry is a clear example of industry convergence. During the past years numerous factors such as globalization, deregulation, harmonization, and always shorter technological life span have radically changed the structure of different industries. In particular, an interesting aspect of these changes is the blurring and redefinition of industry boundaries, in other words, the convergence of different industries into a new one. This brought to the definition of what is an industry convergence: "*the converging of two or several hitherto separate industries"* (Weaver, 2007). Convergence can be defined also as *"the blurring of boundaries between industries by converging value propositions, technologies and markets"*. (Bröring, 2010)
It is a phenomenon observed in many industries, new technologies and their rapid diffusion across industry boundaries are the main drivers for industry convergence.

The Smart Building industry represents a convergence in complements; this particular type of convergence, opposite to the substitutes convergence, occurs when products or services that were previously unrelated are bundled together to form a new combination and integrated class of products/services with added value for end-users. This is clear in the Smart Building industry, where products/services that were enough in the past are now coupled with additional, IT-based, ones to enhance people experience and deliver the new value propositions. Think about a security camera that not only performs its intended task, recording, but now delivers a value-added service, facial recognition and access control, through the use of an IT-based service, Artificial Intelligence.
This new technology deployment is not easy nor simple to develop. The aforementioned IoT-based solutions require integrating thousands of different products and services (connected devices, networks and clouds, data analytics, machine learning, mobile applications) with the traditional building infrastructure merging them into a seamless and stable one. *(*PwC. *"Smart Building technology deployment: A systemic approach to enhancing operational efficiency and occupant experience."* 2019)

Introduction

Industry convergence represents a new condition for innovation and for innovative strategies in particular. Since the new industry requires new knowledge and competences, that belongs to different traditional industries and are industry specific, to be combined and integrated there is no player, notwithstanding from which industry it originates, that possess all this competences and is able to innovate and act successfully as a lone hero in the new market. (Bröring, 2010)

If firms want to participate and success in innovating and have business in a new converged industry, they must open up their process and acquire externally competences, knowledge and technologies that they don't have internally and whose development from scratches would require too high investments, monetary and in time terms. Then an Open Innovation approach is needed for the success in the market. "*The more a firm deviates from its core industry, the more competence gaps it will encounter, and the higher will be the need to open up the innovation process and implement an Open Innovation design with partners from different industries bringing together complementary competencies."* (Bröring, 2010).

As Bröring described clearly in her paper *"Developing innovation strategies for convergence – is 'open innovation' imperative?",* Open Innovation is imperative for innovation in industry convergence, is crucial whenever capabilities' requirements change, and the firm's owned capabilities are not enough anymore. Open Innovation is the only way that a firm has to capture the maximum value from the market and to gain a leading position in it. A Closed Innovation strategy is not an option for those companies that chose to actively pursuing activities and business in the newly emerged industry.

Open Innovation is fundamental and in order to employ such approach, firms must scout the right complementary competencies needed and be prone to form alliances with these companies.

Resorting to partnerships and collaborations is a founding principle of the Open Innovation approach. The use of alliances to access knowledge, technologies or different market areas represent one of the best examples of how the Open Innovation paradigm pushes to look outside the firm boundaries to find new opportunities. And, at the same time, as has been explained before, the adoption of it in presence of an industry convergence is crucial to perform in the new market. Creating strategic alliances, joint venture and M&A is one effect of the convergence of industries and the only way to access the capabilities needed to innovate and perform in the converged industry. On the other side, Smart Buildings are always more interesting, actual and needed in our

society, their presence is growing, and they are the best candidates to lead the technological renovations of cities.

Understood the dark spot left by the literature in a clear definition and taxonomy of the adoption of the Open Innovation paradigm in the Smart Building industry, this thesis aims at filling that gap. Showing which actors, belonging to different traditional industries, resort to partnerships and collaborations, with whom, and for what reasons are these created, by conducting an exploratory, qualitative empirical analysis in the Smart Building industry.

1.2. Research structure

The research is structured in seven chapters.

The first chapter gives a brief explanation of the motivations behind this research, a brief introduction of the themes tackled, and the research question is formulated.

The second chapter is a literature review about the concept of Open Innovation. Is considered what numerous authors have identified and discussed about the definition of Open Innovation and the differences with the classic closed model. The two big typologies of Open Innovation, inbound and outbound, are taken in consideration, described and show how these impact on a firm's performance. Particularly, how these bring both monetary and not monetary benefits. Then the process to move from a closed to an open approach is analyzed and as last part the actors involved in the process are described regarding their strength and offering capabilities. Lastly, the research framework is presented where the research question is presented and formulated.

In the third chapter an empirical setting of Smart Buildings is done. Initially providing a definition of what a Smart Building is and its growth history. Then the main enabling technologies are taken into consideration. Describing them shortly and showing how are important to the development of the Smart Building industry. The last part of the chapter is dedicated to the regulatory environment; analyzing the newest European regulation and specifically a section about the Italian regulation, since all the data are gathered referring to the Italian market.

Introduction

Chapter four describes the objects of the research and the methodologies used. A brief statement of the research question is re-given, passing then to the description of how data were gathered and analyzed. Followed by a description of the players' cluster that have been made. In the last part of the chapter a framework summarizes and explains the understanding of the industry wanted during the data gathering part.

In chapter five, the findings from the analysis of data are shown and are discussed the results of the empirical analysis. Firstly, all the partnerships created inside each clusters, previously defined, and their reasons are showed and deeply described; then, in the following part a comparative analysis is held defining patterns and showing which are the most overall resorted partnerships, describing these and the main competences and knowledges that have led to the resorting partners. Lastly, three case studies are taken into consideration, described and, in every one of them, is highlighted which and how partnerships were fundamental to the final outcome.

In the sixth chapter a response to the research questions is given and are identified the main behavioral patterns from the analysis of data. Moreover, the limitations of the research and the possible future development are listed. With a part that describe the implications that this thesis will bring to practitioners.

Then it follows the references in the seventh chapter and lastly the annex.

Introduction

CHAPTER 2: LITERATURE REVIEW

The aim of this chapter is to review the academic literature on Open Innovation. The keywords used in the search were: open innovation, collaborative innovation, partnership, cooperation. In the first part of the chapter the concept of Open Innovation is introduced, followed by a comparison between the open and the closed innovation model. The third part of this analysis focuses on the two typologies of Open Innovation and their impact on the firms' performances. In the fourth part the process that a company must go through to change from the Closed to the Open Innovation model is analyzed and the last part, fifth, is dedicated to the sources of external knowledge that can be involved and their impact on the involving company. In the very end a clear illustration of the research question is presented.

2.1. Open Innovation: a definition

Open Innovation has been defined as: "*the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively*" (Chesbrough, 2006). It's then a new way of intending innovation, not bond just to the innovative capability of the property R&D laboratories of firms, like the classic model of innovation, but accepting and being ready to adopt ideas and technologies not developed in house but that come from competitors, universities, start-ups, firms that operate in other industries, research laboratories, external consultants, specialized firms, inventors, retired specialists, Ph.D students and so on. Not only to fasten the innovation process up, but to grasp each possibility offered by an innovative environment. Chesbrough says even more, in fact a firm shouldn't just internalize external knowledge but also consider the possibility of open their business range to other markets than the core one, exploiting internal or external generated knowledge to reach markets or industries that are not the core of the firm, opening up in this way to new business lines. Open Innovation substitutes the idea of a firm as only source of product or service innovation with an innovative environment, where firms should float in and be ready to identify innovative opportunities and who owns the knowledge to exploit these possible innovations. This new concept

brings per se the need of partners and the systematic adoption of partnership in the innovation process rather than resorting to internal R&D as in the classic innovation model.

The differences between Open and Closed Innovation

In the classical, closed, innovation framework all the knowledge, scientific and technological, was internally generated by one firm, then some projects were selected and developed into new products, and effectively lunched on the market, while others were abandoned. These happened for many reasons, like lack of scientific, technological or financial resources or inability to find a market's demand in that particular industry where the firm operates. (Leitão, 2018)

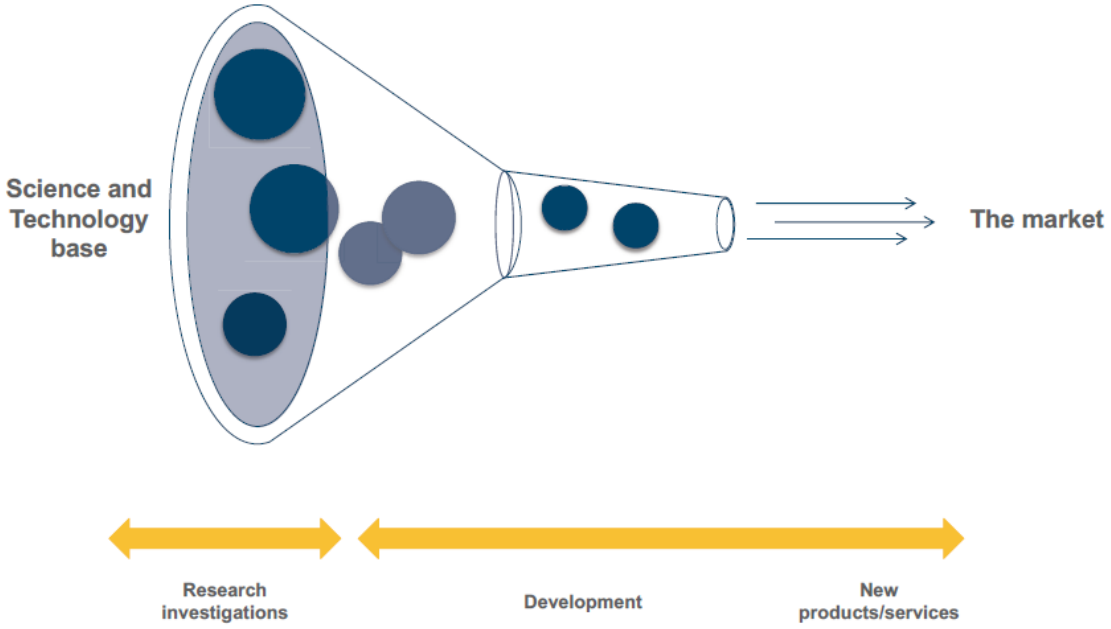

Figure 1: Closed Innovation funnel

As can be seen in the funnel above there was only one way of developing and lunching these projects, and the system was a closed one. "*Companies must generate their own ideas, and then develop them, build them, market them, distribute them, service them, finance them, and support them on their own''* (Chesbrough, 2003).

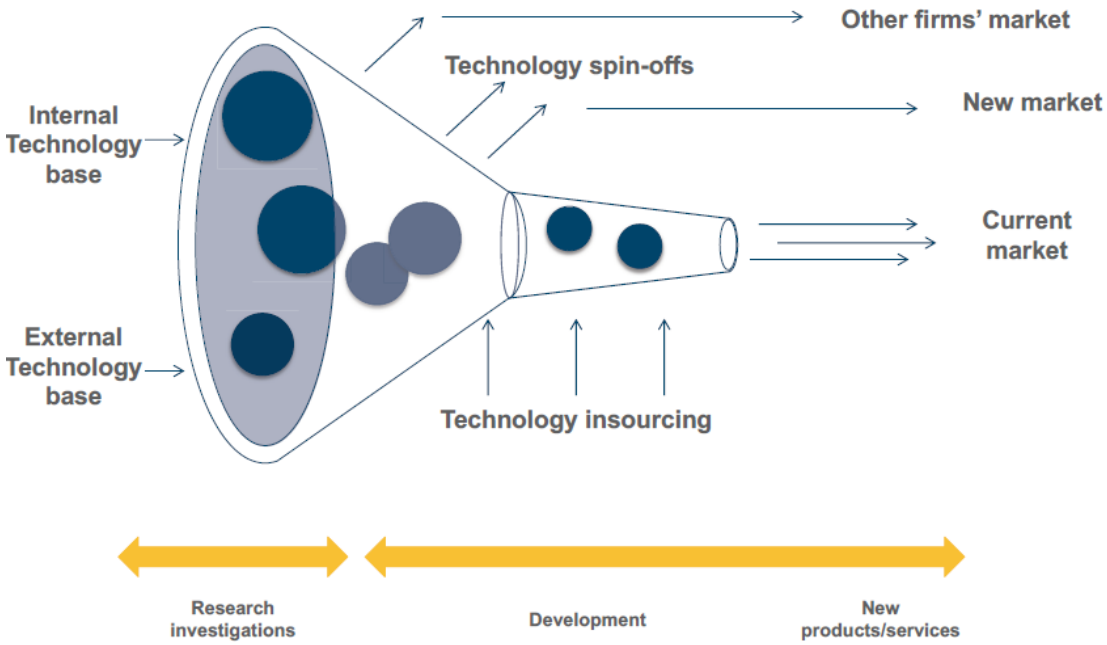

Figure 2: Open Innovation funnel

Conversely, in the Open Innovation approach knowledge and ideas come from internal and external sources, and new technologies can enter in different phases of the innovation process, these knowledge flows are used to reinforce the innovation process and to develop new market paths, figure 2. That can be exploited by the firm letting the innovation process flow into the market in many different ways (namely, out-licensing, new ventures spin-off, sale of innovation projects, joint ventures). (Leitão, 2018)

These two main advantages and practice of exploiting the Open Innovation paradigm are called: Inbound Open Innovation, the process in which a company enriches its own knowledge through external stimuli by monitoring the external environment. The company exploits external ideas, technologies and solution that needs to enrich its internal innovations or solve internal innovations problems, and Outbound Open Innovation, the company canalizes its innovations into external markets or organizations that better suit their diffusion and exploitation, to delivery as fast as possible the innovation. (Gassmann, Enkel 2004).

"No matter who you are, most of the smartest people work for someone else[1]."

[1] This notion is often labeled as *Joy's Law*, attributed to Sun Microsystems co-founder Bill Joy; see, for example, accessed October 17, 2017, https://en.wikipedia.org/wiki/Joy%27s_law_(management)

As stated by Dahlander and Gann, in their paper *"How open is innovation?"*, Open Innovation is not a binary classification Open versus Closed, but it's more complicated and it must be considered as a continuum. Ranging from Closed to Open and embracing different degrees of openness; particularly, some aspects of the innovation process are open, and others may be closed.

	Inbound innovation	Outbound innovation
Pecuniary	Acquiring	Selling
Non-pecuniary	Sourcing	Revealing

Table 2: Structure of different forms of openness

The table 2 above shows how Open Innovation can be divided in two big categories, that present sub-categories inside of them: Inbound Open Innovation and Outbound Open Innovation, a deeper explanation of these is given in the next paragraph.

Focusing, instead on the four sub-categories defined in the table 2 the two authors described four degrees of openness of the innovation process. (Dahlander and Gann, 2010)

- Reveling: *"This type of openness refers to how internal resources are revealed to the external environment."* As stated in the table this approach doesn't have any pecuniary aim but seeks long-term indirect benefits for the reveling firm. This brings both advantages and disadvantages; the selective reveling of some technologies to the public or to elite circles boost the incremental innovation process, enabling competitors to build upon each others' work, making the industry more dynamic and proliferous. On the other hand, the obvious disadvantage is that capturing the benefits from its own innovations becomes more difficult, since better positioned competitors can take advantage from the technology reveling.
- Selling: *"This type of openness refers to how firms commercialize their inventions and technologies through selling or licensing out resources developed in other organizations."* The pecuniary aim is here clear; companies that possess a strong innovative capability but lack of complementary assets to commercialize their inventions could resort in commercializing externally these to increase their profits, the choice between selling and out-licensing depends on the IP protection that the inventor has on the technology. Nevertheless, the market for technologies present significant transaction costs in transferring technologies between organizations, and, also, it could be difficult for the

involved firms to evaluate in advance the potentialities of the exchanged knowledge, causing misalignments between the two firms.

- Acquiring: *"This type of openness refers to acquiring input to the innovation process through the marketplace."* This process refers, in particular, how firms license-in and acquire expertise from outside; enabling the company to avoid the R&D expenses, in monetary and time terms, and have new, ready to use sources of knowledge and technologies. But this come with a great challenge: understanding which is the best knowledge to source in. If the knowledge is too similar, the purchase won't create innovative combinations, if it's too distant is hard to align with its own practices. The relation between the knowledge relatedness of the acquiring and acquired firms is curvilinearly related to innovative performances.
- Sourcing: *"This type of openness refers to how firms can use external sources of innovation. Firms scan the external environment prior to initiating internal R&D work. If existing ideas and technologies are available, the firms use them."* The main advantage brought by this process is the ability of firms to create a synergy between their own internal processes and the externally available ideas and knowledge. In particular, firms, can use that externally generated knowledge into the development of internal products/services. The drawback of this process is that firms can over-search spending too much time looking for and relying to external sources of innovation.

A spontaneous question arises here: What is the process that enables most the profit possibility for firms? The answer is easy, there is not a perfect process. It might be necessary, for companies, to keep some aspects of the innovation process closed and open others (Dahlander and Gann, 2010). There is not a right or wrong choice, but each company should first understand the market, its complementary assets, the innovation's typology and many other aspects before addressing an Open Innovation process, adopting the process that best fits its own company, the industry, the time and the customers.

2.3. The impact of Open Innovation on the firms' performances

Open Innovation has gained always more importance and it has become the gold standard of innovation's process because provides strategic advantages and improves the economic performance of firms. Furthermore, this new paradigm contributes to the creation of new business models and the strengthening of innovation networks among different partners all along the value chain of a product. Other factors that will likely support this trend in the future are the diffusion of innovation intermediaries and the always tighter intellectual property regime, the growing mobility of technical and knowledge professionals, the birth and expansion of the market for technologies, moreover, modern technologies are becoming always more complex, making always more difficult, also for big companies, to afford to develop new products all alone. Consequently, the trend toward R&D partnership and alliances is always stronger. (Bianchi, Cavaliere, Chiaroni, Frattini, Chiesa, 2011)

Acknowledged the huge benefits that Open Innovation has in terms of access to know-how from distant fields, higher flexibility, reduced time to market, risk and cost sharing, it has also drawbacks, lower knowledge appropriability, loss of control over core competencies, moral hazard, and individuals can perceive it as burdensome. As they may be lacking the preparedness to work with highly innovative partners, or with partners that have a completely different cultural mindsets, like a huge incumbent with a newborn start-up. Or because they prefer to rely on old, long term, established partners because of the easier knowledge exchange or because of already defined interaction routines. (Salter, Criscuolo, Ter Wal, 2014)

2.3.1. Outbound Open Innovation

Outbound Open Innovation in many firms is part of the corporate strategy and it goes beyond the marginal activity of commercializing unused technologies, this in fact contribute massively to the firm performances (Fosfuri, 2006, Lichtenthaler 2008, 2009). In fact, closed strategy limits the ability of a firm to achieve the strategic benefits that are instead brought by Outbound Open Innovation (Lichtenthaler 2008). As stated by Kutvonen (2011) in his paper, the commercialization of technological assets goes way beyond the mere sale of their own products, services and processes. But it also includes different other methods, such as licensing, patent selling, spin-offs, and it could also involve non-monetary compensations. External exploitation of knowledge is defined as "*an organization's deliberate commercializing of knowledge assets to another independent organization involving a contractual obligation for compensation in monetary or non-monetary terms*", (Lichtenthaler, 2005).

2.3.1.1. The monetary incentives of resorting in Outbound Open Innovation

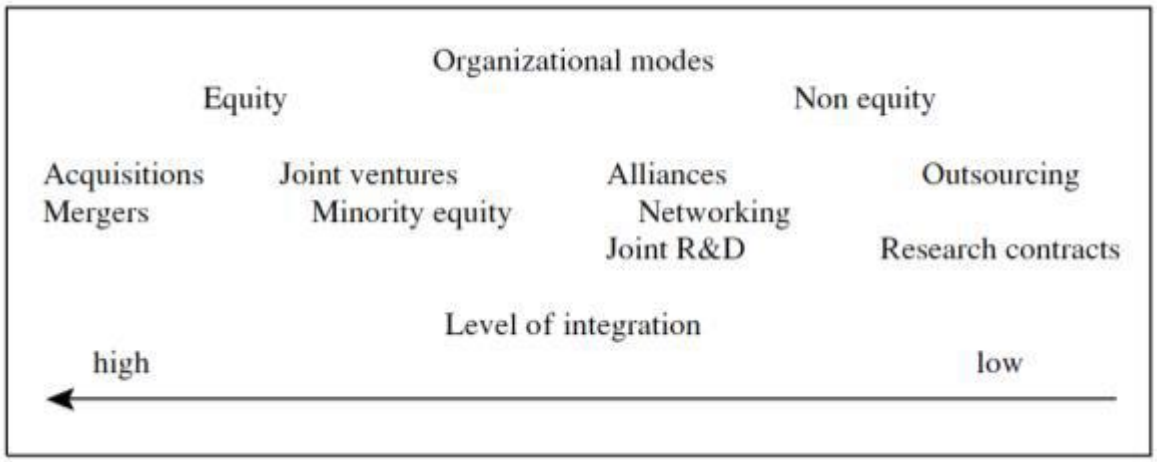

Figure 3: Organizational modes of Outbound Open Innovation

As can be seen in the figure 3, the typologies of relations used to externalize a technology are very wide. Those depends mainly by the level of integration wanted and needed inside a company, it's crucial understanding the right integration level required by the situation, the best fit is the mode that enables complete control and monitoring of the externalized knowledge, to avoid opportunistic

behaviors, but that gives to the external partner enough space to freely operate, not being smothered.

- Mergers and acquisitions: merge between two companies, one of the two firms is interested in some specific resources, owned by the other firm, not easily transferrable, i.e. organizational capabilities or intangible assets (brand, reputation, technical knowledge). So, it buys or merges with the target company.
- Joint venture: type of alliance, two companies create a new, independent firm with shared ownership, to generate and exploit new resources.
- Minority equity: a company buys a minority part of shares of another company to gain some rights on the latter one's resources.
- Alliances: exchange relationship of contractual nature between independent entities with a long-term horizon that limits ex-ante partners' future behavior.
- Networking: formation of social relationships and networks at conferences, public or corporate events, or inside the universities.
- Joint R&D: collaborative research and joint publishing of some specific topics between two companies, or between companies and universities or research centers.
- Outsourcing: buying externally a certain input needed in the innovation process without any significative knowhow exchange.
- Research contract: activities commissioned by companies to universities, consulting firms, research centers, to have a deep understanding on a specific topic.

2.3.1.1. The non-monetary incentives of resorting in Outbound Open Innovation

Instead considering the non-monetary incentives, authors defined how it's impossible to make "keep or sell" decision solely on a firm and not considering the firm's environment (Gambardella, 2007), depending, in fact, on the firm's particular environment it may be beneficial for a firm to engage or not in transferring externally a technology (Teece, 1998; Fosfuri, 2006). In particular an environment characterized by a strong patents protection positively affect the possibilities of a firm of profiting from Outbound Open Innovation (Gambardella, 2007). A sufficient patents protection enables in fact a company to capture the benefits from external technology commercialization. Thus, companies in strong patents protected environment, should see outward technology transfer

as an opportunity to capture an excess of value from unused internal technology. Keeping in mind, as in the Inbound Open Innovation, that, most of the time, this activity is complementary rather than substitutive to their core business. This is not always true for every kind of companies, there are in the markets companies that have high development capabilities but low internal commercialization capacities, this companies focus then on the development of new technologies that then offer on the market for technologies, resorting to out-licensing or spinning-off for their commercialization. A trend in the market that is growing and that would increase, per se, the need and the number of companies that will resort to external technology commercialization (Arora and Fosfuri, 2003).

Always considering Kutvonen's (2011) work, the figure below shows clearly all the strategic (non-monetary) external technology commercialization (ETC) objectives are grouped in six categories by the general overbearing motive, each one with different strategic benefits that could be the firm's objective in the external technology exploitation.

Objective group	Individual strategic objective
Gaining access to new knowledge	Cross-licensing Entry into technological markets and networks Setting up listening posts for weak signals
Learning from knowledge transfer	Building dynamic capabilities Building reputation Learning from knowledge transfer
Multiplication of own technologies	Standard setting Profiting from network effects Geographical and product market expansion
Controlling technological trajectories	Controlling technological path dependency
External exploitation as a core business model	Actively developing for external parties
Exerting control over environment	Maintaining technological leadership Defensive out-licensing Creation of market ecosystems Guaranteeing freedom to operate Feeding entry barriers

Source: Kutvonen *et al.*, 2010

Table 3: Strategic non-monetary objectives

Gaining access to new knowledge: the new, fast technologies' lifecycles make very important accessing to key external technologies, and the fist acknowledged strategic object for external knowledge exploitation is gaining access to another's company technology portfolio. To do so there are mainly three ways:

(i) Cross-licensing, inducing other companies to engage in licensing agreements.

(ii) Entry in a technological markets and networks, a firm use its knowledge asset to enter in a new market, to facilitate future relationships with incumbents or strengthen its position as known company in the industry for future transactions, lowering transaction costs.

(iii) "Listening post", the firm proactively insert itself in a profitable environment to catch signals of weaknesses and prepare to make a move.

Learning from knowledge transfer: each transaction involves an organizational learning opportunity and it could lead to the understanding of a firm's learning curve. Technology transactions may lead to:

(i) Building of dynamic capabilities, adapting to routines and learning from them through previous interactions firms could reduce the transactions costs in the market for technology.

(ii) Building reputation, the firm interaction with player in the market improve its reputation attracting always better candidates for future transactions.

(iii) Learning from knowledge transfer, firms may leverage the knowledge transactions to learn from outside the firm's own business, building new skills and competence in specific areas.

Multiplication of own technologies: here the aim of a firm is to increase as fast as possible the penetration of its own technology in a market, these can be done through:

(i) Standard setting, where through aggressive out-licensing a company obtain almost the monopoly of the market for that technology.

(ii) Profiting from network effect, very similar, creating a network effect that locks in customers and enables to company to have a position of strength, very likely a company open its IP on the technology to gain the lock-in effect.

(iii) Out-licensing, that enables market expansions in geographical terms and industrial ones, for example international licensing.

Controlling technological trajectories: controlling technological path dependency, a firm may be able out-licensing a technology to jump one part of the development to the very next. Giving out technologies to have others to improve them so that the inventor can use these developments.
External exploiting as a core business model: actively developing for external parties, there are in the markets companies that have high development capabilities but low internal commercialization capacities, this companies have as focus the development of new technologies that then offer on the market for technologies, resorting to out-licensing or spinning-off for their commercialization.
Exerting control over the market environment: this is a very important, strategic category, though which companies leverage the external technology exploitation to maintain the control of the market, this can be conducted though:

(i) Maintaining technological leadership, a big incumbent may license its technology to its major competitors to direct their focus in inventive activities on other areas, leaving that technology field to the incumbent.
(ii) Defensive out-licensing, license-out a specific technology to competitors, focusing their activities on it, enabling the licensee to concentrate on another technology, which represents a different market segment or which is superior in the long term.
(iii) Creation of market ecosystems through complementary products and services, these ecosystems could create additional benefits and synergies, creating interoperability and reciprocal needs.
(iv) “Freedom to operate”, the most important objective is guaranteeing it. In other words, using knowledge assets as bargaining chips in cross-licensing arrangements with select competitors, to avoid patent infringement in industries with high technological overlap and rapid development cycles.
(v) Feeding entry barriers, use external technology exploitation to raise entry barriers against dangerous competitors by licensing-out technologies to weaker, not dangerous firms, lowering in this way the market attractiveness.

2.3.2. Inbound Open Innovation

"*It is no longer just a matter of hiring the most talented and creative people or establishing the right internal environment for innovation. The new leaders in innovation will be those who can understand how to design collaboration networks and how to tap their potential*" (Verganti and Pisano, 2009). External knowledge and technologies can be accessed by companies in many ways, engaging in different types of agreements with independent companies. In particular a company engages in various relationships depending on the extent and the intensity to which the company wants to rely on external knowledge sources (Saebi, Foss, 2014). Agreements typologies can then be mapped into two dimensions, regarding the "breadth" and "depth" of knowledge search. Breadth identifies the diversity and dimension of external sources of knowledge, while depth refers to the intensity with which companies take knowledge from external sources, often measured with the number of external partners that are deeply integrated in the company's innovation activities.

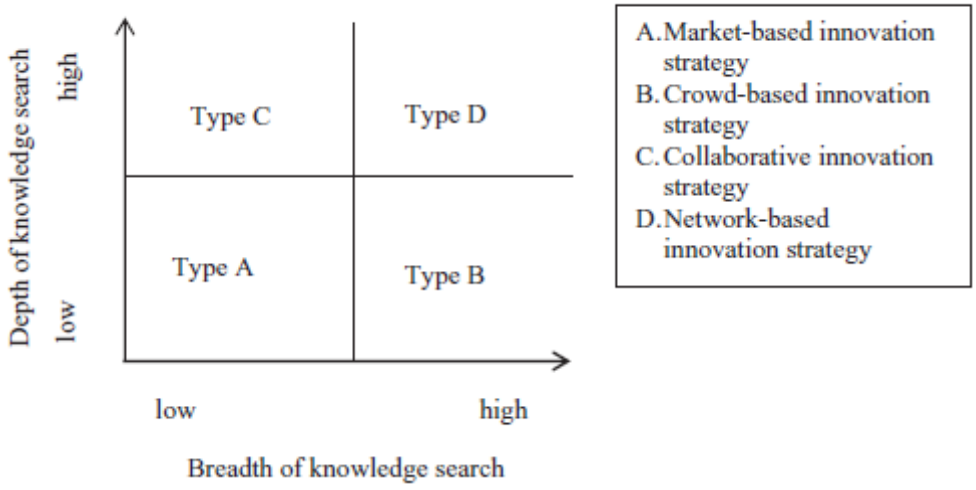

Table 4: Typology of Inbound Open Innovation strategies

As showed in the table 4, four main quadrants can be identified that represent four different strategies for Inbound Open Innovation. Market-based innovation strategy (low depth/low breadth), this strategy is characterized by an acquisition of knowledge from the market itself, with low diversity and integration levels. Examples are inward-licensing of IP, R&D outsourcing or acquisition of start-ups. This strategy is suitable to benefit from market-ready innovations or complementary resources or technologies. Crowd-based innovation strategy (low depth/ high

breadth), knowledge comes from a large number of actors, namely, crows. Companies can access the distributed knowledge of crowds or communities thanks to low communication costs. Engaging user communities enables to reach the collective intelligence of a large number of users. Collaborative innovation strategy (high depth/low breadth), in this case a company enters into collaborative agreements with few knowledge-intensive partners, for example lead-users, universities, research institutes, or other companies. The deep integration of the partners into the company's innovation process ensure frequent interactions and the development of mutual trust, easing the process of transferring of tacit knowledge between the two parties. Network-based innovation strategy (high depth/high breadth), companies like in the above case deeply involve partners to ensure the effective knowledge transmission, but the knowledge is widely dispersed. Then a company engages a network of relationships with many external players creating then an innovation ecosystem, consisting of individuals, communities and other organizations.

2.3.2.1. Collaborative Architecture

Another perspective about the different typologies of Inbound Open Innovation was given by Verganti and Pisano. For the two authors it's crucial for firms before jumping into relationships consider their structure and organizing principles, what they defined with "collaborative architecture". They developed a framework that define four main types of collaborations, defining those through two simple questions: "*given your strategy, how open or closed should your firm's network of collaborators be?"* and *"who should decide which problems the network will tackle and which solutions will be adopted?"*. Therefore, collaborations differ significantly in the degree of openness to people and in their governance form. If the openness of the network is pretty self-explanatory, the governance is about which part owns the power to decide which problems are more important, how they'll be solved and if a solution is acceptable and implementable. First choice is about openness o closeness of the network, an open network implies that everyone can enter it, so bigger interactions with many players and then more ideas. A closed one instead allows the participation of only selected actors, so they are more competent and aligned with the firm's target. It's crucial to understand if the firm needs a close or open network; the close network implies that the company has identified the knowledge domain in which the best solution to its problems reside and that the company is able to pick the right collaborators in that field, that means high

information costs. An open network, conversely, has the potential to gather a vast number of ideas, attracting an extreme large number of people. So, the costs of identifying the knowledge domain and the best collaborators are non-existent. Open modes have also disadvantages, first of all they are not as effective as the closed one in identifying and attracting the best players. This caused by the inverse proportion of participants and selected solution, with the increase of participants and the lack of an evaluating system to define the best problem solvers it's more difficult to choose the best solution. For this reason, the best parties will more likely participate in closed mode. Open modes work very well when the average solution is very close to the ideal one, making not so relevant to miss out the best solution. Moreover, open modes are adoptable only if the screening process is extremely cheap and fast, in other words, if it's feasible for the company to evaluate the proposed solutions at very low costs. Moreover, it must be very easy to participate to open modes, this is often possible when the addressing company is not looking for a whole solution but only for a part of it. If the firm can partition the problem into small well-defined chunks that players can work autonomously on.

Second choice is about the governance: flat or hierarchical? This choice is led mainly by the need of one firm to define the direction of the innovation efforts, choose the solution and capture the most of its value. In the hierarchical form one specific firm has this authority, in the flat form all the decisions are made jointly or decentralized. A hierarchical mode is preferred when the addressing company is able to define the problem, evaluate the proposed solutions and choose the best one. Flat governance is, instead, preferred when there is no company that has the breadth of perspective or capabilities needed, or when collaborators have a vested interest in the solution of a problem, they will in fact collaborate only if they'll have the possibility to have a voice in the decision making process. The main advantage of this governance type is the shared costs, risks and technical challenges of innovating.

Beside the choice of the most suitable of all four collaboration, designing incentives, both financial and nonfinancial, is crucial to attract external collaborators. Particularly important ones are the nonfinancial ones, sometimes in fact incentives such as: higher visibility and enhanced reputation among a group, the psychological fulfillment of pursuing a strong interest and the chance of using the solution in their own business can overcome the financial ones, based mainly on fees and royalties.

There is not a right or perfect mode, each company should take into account its strategy and its capturing value capabilities and choose consequently. And be aware and ready to change collaborative mode with the evolving of its strategy, because the right model depends solely on the firm' strategy.

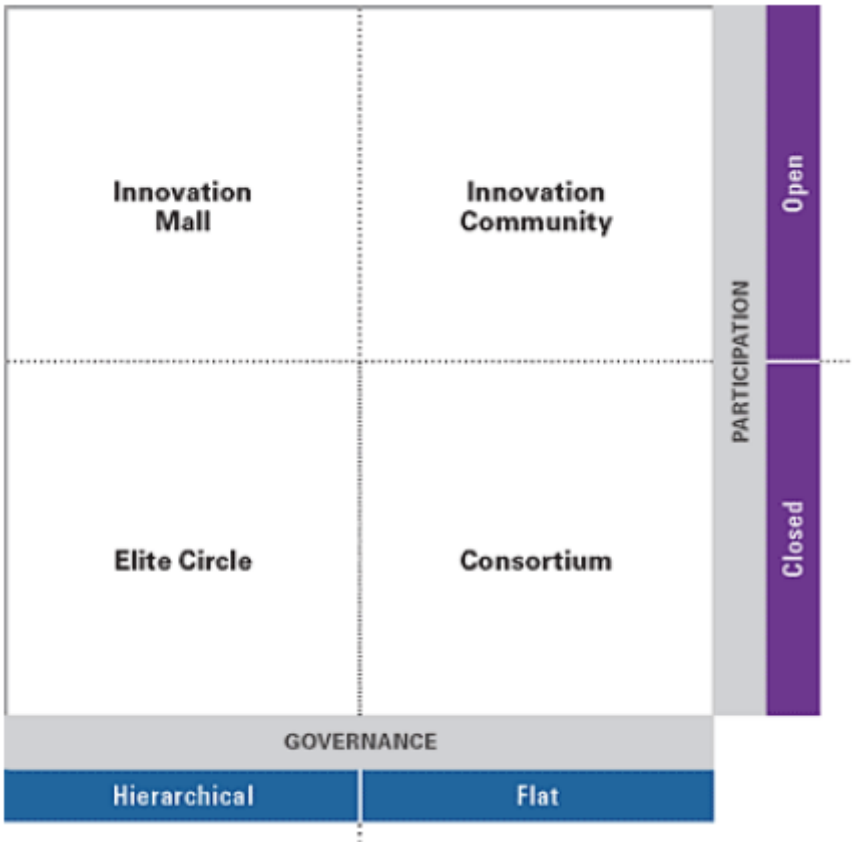

Table 5: Collaborative Innovation framework

As shown in the table 5, four modes of collaborations can be identified: an *elite circle* (close and hierarchical), an *innovation mall* (open and hierarchical), an *innovation community* (open and flat) and a *consortium* (closed and flat).

(i) *Elite circle:* A selected group of participants chosen by a company that also defines the problem and picks the solutions. I.e. Alessi's handpicked group of 200-plus design experts.

(ii) *Innovation mall:* A place where a company can post a problem, anyone can propose a solution, and the company chooses the solutions it likes best. I.e. InnoCentive.com.

(iii) *Innovation community:* A network where anybody can propose problems, offer solutions, and decide which solutions to use. I.e. Linux open-source software community

(iv) *Consortium:* A private group of participants that jointly select problems, decide how to conduct work, and choose solutions. I.e. IBM's partnerships with select companies to jointly develop semiconductor technologies.

2.4. The process to adopt an Open Innovation model

The process to adopt the Inbound Open Innovation method is made of two fundamental steps: (i) the transition from a closed to an opened innovation method, (ii) the procedures adopted to implement the method. Using as reference Chiaroni, Chiesa and Frattini work in the paper *"Unravelling the process from Closed to Open Innovation: evidence from mature, asset-intensive industries*", we can describe the transition into three big steps, unfreezing, moving and institutionalizing. Moreover, the authors identified the four main dimensions along which the change from close to open innovator takes place and that must be stimulated to make this change happen.

These are:
- networks
- organizational structures
- evaluation processes
- knowledge management system.

The unfreezing phase, in this phase the networks are still based of employees' own network and contacts. New organizational structures are created, to overcome organization inertia and routines, new business units or independent R&D teams were created. The evaluation process is changed, some figure starts to appear, like projects managers, and new routines, like periodically meetings bridge between R&D and corporate level, but there is also a use of external actors to assess the quality of the process. The knowledge management in this phase is almost not existent, the firms start to file patents on existing knowledge, within the firm. The moving phase, the personal networks are internalized into the firm level and increased, companies start creating strong bonds with university mainly but also research centers. New organizational structures are created with the aim of managing research collaborations with universities, and pilot projects are defined to test the collaboration with universities. A more formalized and explicit evaluation process is introduced, to

assess the potential of accessing external partners and to challenge the "not invented here" syndrome. Knowledge management start to appear, using information technologies for supporting project management activities and innovation scouting activities. The results achieved in the implementation of the inbound dimension of Open Innovation are consolidated and institutionalizated in this phase. The partnerships with universities or research centers are consolidated and become long terms ones. More than organizational structural changes there is the introduction of new roles, in this phase, like knowledge scouts and innovation champions, and the use of dedicated people to search the external environment for potentially valuable ideas. The evaluation process adopts general indicators and eventually of derived information performance measures for project managers. The knowledge management system in this phase gains a very important role, in particular patenting is, explicitly, included in the strategic plan.

The whole Inbound Open Innovation process can be then summed up into three phases (West and Bogers, 2014). Namely, (i) obtaining the innovation from external sources, (ii) integrating the innovations and (ii) commercialize the innovations. The process is unfortunately not linear and there is a fourth phase that may occur at any phase of the innovation process; this is the interaction phase.

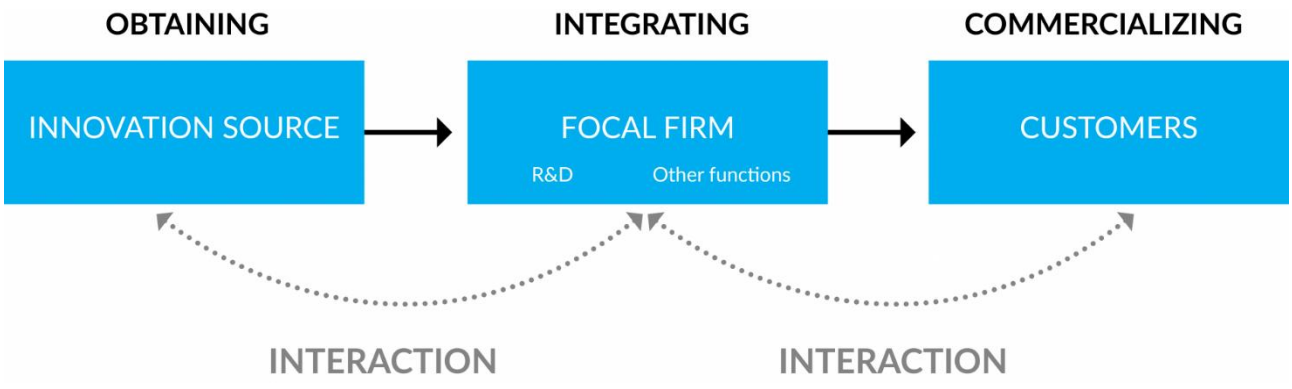

Figure 4: The four phases of the Inbound Open Innovation process

The first step is obtaining knowledge and innovations from external sources, the sources for external innovations can be multiple, could be universities, research centers, suppliers, customers, the crowds and competitors, a key point here is to find the "perfect match", so the best partner to have a relationship with. There is a trade-off between the innovation capabilities of a potential partner and the distance of the two future partners, in cultural terms and core business distance. If cultural differences can be overcome with organizational structures (spin-off, equity ownership, joint

ventures), high differences in technologies and core business can be detrimental in the integrating phase, being difficult to digest. A patent-based approach is a useful tool to search potential partners, in fact patent include R&D information of a specific technology and are easily accessible from public databases. A patent analysis that lead as final result to technology similarity indicators can help companies in understating if a certain partner is too radical and far from them (Jeon, Lee and Park, 2011). Second step is about integrating the knowledge and innovations, partially this phase is eased by a cultural imprinting of the company, its open mind and willingness to accept external innovations, not suffering from the "not invented here syndrome", so the difficulties to accept something that wasn't created inside the company but it's a result of others. Moreover, there is a particular factor that influences the capability of a firm to acquire, assimilate and use technological knowledge developed elsewhere, and that is its "absorptive capacity". The "absorptive capacity" is fundamental in an Open Innovation paradigm, but it has to be nurtured, and to be able to effectively absorb external knowledge a firm must undergo a continuous process of experimentation, adaptation and investment in R&D. Avoiding the thought of substituting their innovation process with the systematic internalization and exploitation of the external knowledge, nevertheless this is a quite common practice, *"In our interviews with open innovation managers, it became clear that firms' open innovation programs often pay little attention to the process of assimilation of the external ideas identified. Many organizations see open innovation as an opportunity to "leapfrog" the process of discovery of novel ideas rather than as a laborious process of assimilation*" (Salter, Criscuolo, Ter Wal, 2014).

To increase its absorptive capacity a firm should create a corporate culture and internal organization aimed at integrating the absorbed knowledge. Starting from the knowledge management system, used to support the identification, diffusion, sharing and transfer of knowledge inside and outside the firm, and most of all increasing the process of technology intelligence, defined as "*the process of systematic acquisition, assessment and communication of information on technological trends in order to detect opportunities and threats in a timely manner*" (Lichtenthaler, 2007) so the constant research and focus on competitors and other firms' technological environment to gather knowledge to be used than internally. And create new incentives and rewarding systems, with more opened goals and metrics that reward particularly open behaviors of employees, like the identification of new partners, the transfer of an external idea across the boundary of the firm, or the utilization of an external resource on internal projects or even awards or prizes for those that excel in external engagement (open innovator of the year).

Moreover, as stated by Salter, Criscuolo and Ter Wal, skepticism could be overcome through a deeper immersion into the partner organization and with regular site visits to (potential) external partners. These are important ways in which Open Innovation R&D professionals are able to better appreciate the value of external partners and thus reduce the perception of external engagement as "second-best." These formal practices enable organization's R&D staff to become more deeply immersed in the partner organization.

For example, IBM assigns its distinguished engineers to spend part of their working week in another organization, which exposes them to market and technological opportunities that might otherwise remain hidden and provides deeper insight in the capabilities of collaborators. Encouraging R&D staff to allocate time to external relations on a systematic basis would raise their awareness of the potential benefits of connections with external organizations, and ultimately create a more positive mindset towards the value of Open Innovation. The third phase is about marketing the obtained technologies and gain value form them. To conclude, the interaction phase refers to the fact that such process is not necessarily linear, given that there are typically reverse flows and bi-directional interactions throughout the inbound open innovation process.

Outbound Open Innovation results in a completely different process. Lichtenthaler (2008) before and Bianchi (2011) described the path to follow to adopt an Outbound Open Innovation strategy and set a number of milestones to excel in it. The path is made of five main phases. The first one, (i) the planning phase is the strategic one, the firm should take into consideration how to include the external exploitation of their own technologies and know-how in the strategic plan. How to exploit the technologies externally, allocate people that would face this transaction and, most of all, the monetary part of the transaction. Evaluating the trade-off between the costs and the opportunities/threats. The second phase, (ii) the intelligence phase, is about identifying the most suitable technologies and know-how to be licensed outside the firm, due to technology trends. Possible parties and contractual forms are identified and evaluated. The third phase, (iii) the negotiation phase, the firm disclosures the willingness or intention to sell the technology and how it wants to sell it. This phase is particularly delicate because the firm must disclose the technology to attract parties, to let them know what the new technology is about, but also it should be careful to not disclose too much to avoid buyers to free ride, "disclosure paradox". The interested parties in fact, if too much has been disclosed, can avoid purchasing the technology having now enough knowledge to internally produce it. The fourth phase, (iv) the realization phase is about the identification of the firm which will be granted the technology and transfer of it.

Eventually, the fifth and last phase, the control phase, this phase is mostly about monitoring that the part which the technology has been granted is using correctly and as defined in the contract the technology, to avoid misbehavior or improper use of the technology.

2.5. The sources of external knowledge

Sources of external knowledge and innovations can be different types of organizations and partners. Could be cooperations within the supply chain, involving then customers or suppliers, or outside the supply chain, involving competitors, universities, research centers, consultants, and other types of organizations.

2.5.1. Users

Users and especially lead users are particularly important in defining innovations (Tether, 2001). In particular main advantages of working closely with customers are: accessing to complementary knowledge, thanks to the users' technical know-how, easier asses of the best balance between price and performance, deep understanding of users' behavior, of their needs and what they like or not, enhanced standard setting possibilities from other firms within the same user community. Many inventions originate not from a company but, instead, from the very user (Piller, Walcher, 2006). The two authors in their research showed how the participation of the users in the new product development (NPD) is highly successful and how customers using a particular tool, an internet-based *toolkit for idea competitions* (TIC), improve the product development process, and strongly influence their success in the process. Involving customers can be done in different ways; identifying lead users, pyramiding all the users and select the skilled ones, that have a higher knowledge of the products/market, or using idea competitions, competitions where everyone can participate and give ideas, like the use of TIC. Lead users must be identified ex-ante but their capabilities can be evaluated only after a lead user workshop took place. Instead with the idea competition, the selection of lead users can be made after the competition, not bearing any transactions costs. The first phase, the idea competition, will create a self-selection of best skilled users based on ideas' quality, easy evincible.

Customers contribution to innovation is not always positive but depends from two factors: the degree of radicalness, or innovativeness, of the product and the typology of innovation; utilitarian or hedonic ones. Radicalness is defined *as "the magnitude of change of degree of newness of an innovation"*, namely radical or incremental (Garcia, Calantone, 2002), a utilitarian innovation delivers new technologies or functionalities while a hedonic innovation delivers new meanings through new sensorial or emotional benefits or symbolic value (Candi, van den Ende, Gemser, 2016). Both utilitarian and hedonic can then vary in terms of innovativeness. The involvement of customers could provide high-quality contributions or not depending on the innovation's type and radicalness. In particular involving customers in hedonic innovations would be wrong because of their inability to express their unexpressed needs for new, disruptive products, they would face the need of something only when the product is already on the market (Verganti, 2008). The work of Candi, van den Ende and Gemser identified the best conditions in which is effective involving customers in the innovation process. They find how the level of utilitarian radicalness positively moderates customers' involvement, whereas the level of hedonic radicalness negatively moderates this relationship. Customers' codevelopment, then, is fruitful for radical utilitarian innovations, meaning that the innovation will deliver radically new technologies or functionalities, and incremental hedonic innovations, and unfruitful for incremental utilitarian innovations and radical hedonic innovations, meaning that the innovation will deliver radically new meanings through new sensorial, emotional benefits or symbolic value. For mixed innovations, radical both in the hedonic and utilitarian dimensions, customers' involvement could be highly beneficial under one condition; they should be engaged only for the development of the utilitarian part of the innovation and not in the hedonic part (Candi, van den Ende, Gemser, 2016).

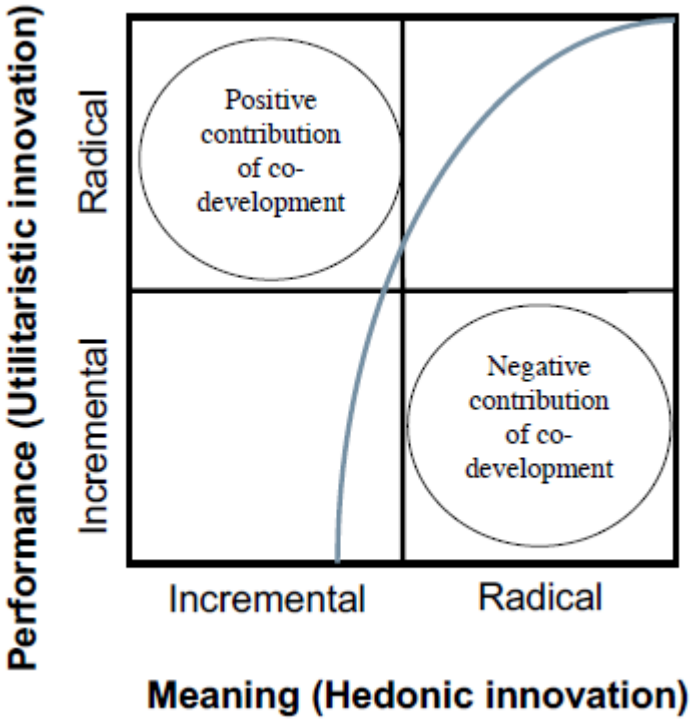

Figure 5: When is useful the users' participation

2.5.2. Suppliers

Partnerships with suppliers share many features and advantages with the customers' one, due to the belonging to the same vertical chain, with the difference that relationships with suppliers examine the "make or buy" context (Tether, 2001). In particular agreements with suppliers can overcome the market failure caused by the innovation environment, where transaction costs are really high due to the incompleteness of information and knowledge. Strategic agreements enable trust and are preferable and more effective respect to transaction, moreover the involvement of suppliers in the NPD has different benefits, development costs are reduced and indirectly also cycle time is reduced. Indirectly because the absence of involvement of suppliers into the NPD would cause a tendency to slow it down through an uncooperative attitude, especially if they are critical suppliers (Primo, Amundson, 2001). Suppliers, like users, are not the right choice for a company that is looking for a breakthrough innovation, for something that goes beyond the already existing schemes and market boundaries. Their involvement brings great benefits to the improvement of products, especially in quality terms. The decisive influence of suppliers on design aspects of the NPD projects resides in the reliability, performances characteristics, and aesthetics.

Moreover, in NPD project's that are characterized by a high degree of technical difficulty suppliers' involvement could have a great impact (Primo, Amundson, 2001).

2.5.3. Competitors

Without doubt, partnerships with competitors can raise suspects, could lead to collusion (Piller, Walcher, 2006). But, actually, firms have many legitimate reasons for these types of alliances, for example:

(i) Standard setting, jointly developed products or services using common standards. Encouraging the customers, suppliers, complementors, to adopt and support the innovation. Much used by small innovative firms that challenge incumbents.

(ii) Firms could be competitors for just a part of their range activities. The firms can be competitors in some markets but not in others. They might find some areas where their strengths are complementary to the development of new products.

(iii) When they face the same problems, especially if these are not caused by competition, i.e. regulations.

2.5.4. Universities

Universities are important contributors to the supply of new scientific and technological knowledge, especially for basic research bond to newborn, pre-competitive technologies, bond then to a long-term strategic plan. In particular, universities, are a source of fresh ideas and knowledge, not bond to any markets of fields, for this reason companies rely on universities for co-development and research about new, highly risky, technologies, that would be too expensive and risky for a single company to deal with (Tether, 2001). The relationship universities-industries has a strong role in generating innovation. This relationship is always more common, favored also by various increase in university's: patenting activity, licensing, academic entrepreneurship, spin-offs, presence of companies in universities with networking, seminaries, conferences. Inside this category of partnership, there is a more multifaced nature of university-industry links, such as patents, informal information exchange, publications and reports, public meetings and conferences, recently hired

graduates, licenses, joint or co-operative research ventures, contract research, consulting, and temporary personnel exchange and others (Perkmann, Walsh, 2007). That can be grouped into four categories: joint research, contract research, mobility and training. These classifications are characterized by a different capacity of tacit knowledge transferring and a different degree of personal contacts

Extent of relational involvement		
High: relationships	Medium: mobility	Low: transfer
Research partnerships Research services	Academic entrepreneurship Human resource transfer	Commercialization of IP (e.g. licensing)
Use of scientific publications, conferences and networking (can accompany all forms)		

Table 6: Involvement of universities in the industry

As in the table 6, relationships are those types of links that require high relational involvement. In these situations, individuals and teams from the two worlds, universities and industry, work together on specific projects producing a common, shared outcome. Conversely, a low relational involvement represent links, or also called knowledge/technology transfer. Mobility is, instead, individuals that move between academics and industry, most of the time toward industry, characterized by an intermediate relational involvement, since some previous links are often maintained after the move. In the Open Innovation's context, the more interesting and valuables are the relationships, as they are long and stable in time (Perkmann, Walsh, 2007). Furthermore, relationships universities-industry contribute far more than just delivering generated technologies and knowledge. Then the typology of link that a company should choose when deciding to collaborate with universities should be well thought and considered accordingly to its strategy. If for emerging technologies acquisition and talents recruitment a medium relational involvement is enough, for developing brand new scientific commercializable innovation it's not and a deeper relational involvement is needed. A more detailed exploration of the relationship-based links can be made distinguishing from research partnerships and research services. This refinement is about the degree of specification of the research, to actually pursue a specific purpose or to gain new knowledge (Perkmann, Walsh, 2007). Research partnerships, also called *"industry-sponsored research"* are designed to generate mainly knowledge with high academic relevance, for publications, future research and development activities. Research services are designed, instead, to pursue an industrial target and are less exploitable for publications. Research services are more

asymmetric, where the firms choose unilaterally the types of expertise or services they require, and the researchers carries out the assignments, this typology defines specific objectives, deadlines and deliverables.

2.5.5. Research centers and consultants

Research centers and consultants are instead a source of applied knowledge and specialists' skills and information more than fresh, new, breakthrough ones, like for universities. Conversely from universities consultants are very useful to solve specific problems attained to their own experience and field, and to match companies with needs and solutions, helping them into understanding their need for innovation (Tether, 2001).

2.6. Research Framework

As profusely described in the two previous chapters; literature has deeply analyzed the Open Innovation model and all its faceting, but lacks a clear definition and taxonomy of its adoption inside a new converging industry, the Smart Building industry. This sectorial application and embracement of Open Innovation aims at exploring and open a new field of research and increase the understanding of how firms behave in the Smart Building branch.

Resorting to partnerships and collaborations is a founding principle of the Open Innovation approach. The use of alliances to access knowledge, technologies or different market areas represent one of the best examples of how the Open Innovation approach pushes to look outside the firm boundaries to find new opportunities. At the same time the need and creation of strategic alliances, joint venture and M&A is one effect of the convergence of industries. Convergence is something that creates discontinuity with the past, that creates big uncertainties, that brings huge opportunities but also huge risks. Therefore, companies choose to resort to partnerships and collaborations to limit the risks, but also to gain faster that knowledge that they lack to offer products or services that match the new requirements of the converged industry, avoiding huge initial investments in technological research. The Smart Building one, is an industry where the interests and offerings of companies coming from different traditional sectors converge, therefore they have to transform their business model and look outside their perimeters. Moreover, this industry shows an always growing interest and increasing investments, not only for the improved experience that Smart Buildings offer to people but also due to the higher sustainability and efficiency of these, something that the world deeply needs in this moment and in the future.

How the main players belonging to different traditional sectors interact and which kind of partnership and collaborations do they create to reduce the risks, to access the needed knowledge or technologies and to perform at best in this new converging industry?
The analysis here conducted shows how different firms, belonging to different clusters tend to partner differently between them, and the different purposes that reside behind these alliances. The additional contribution, and final goal, of this research consists in showing behavioral patterns, recurrences in the alliances held in the industry. In other words, in giving an understanding of how firms that have different aims, dimensions, final customers, resort to different partnerships with one or more players and look for different types of knowledge regardless to their belonging cluster;

to perform and innovate in the Smart Building industry. And how the moving reasons are not the belonging to a predefined industry or cluster but, instead, the customers, the purposes, the aims in the market, the firms' dimensions and the competences needed.

Creating few representative examples that clearly define how the external search for knowledge and competences that characterizes Open Innovation is adopted in the Smart Building industry and how this is the firms' driving reason to partner up; no matter their belonging to the traditional sectors. I will try to answer to this question by conducting an exploratory, qualitative empirical analysis in the Smart Building industry.

CHAPTER 3: EMPIRICAL SETTINGS

This chapter wants to be an explanatory description of what a Smart Building is, what are its main characteristics and functionalities, and which are its main value-added services that provides to the users. A brief paragraph is dedicated to the history of the Smart Building concept, when it was born, what stood for and when the current definition was born. Then is considered the industry that Smart Building represent. Describing what is an industry convergence and showing how this particular one is a clear example of convergence. Then the main enabling technologies to Smart Buildings are taken into consideration and described, showing their characteristics and how are used inside the Smart Building itself. Eventually, the chapter final part gives an understanding of the regulatory environment, with a specific to the smart readiness indicator and the Italian regulation.

3.1. The Smart Building concept: definition, features and functionalities

Over the last few years, the world has started overflowing with "smart" things, as the term has become synonymous with embedding inanimate objects with electronics, software, sensors, and network connectivity that enable these objects to collect and exchange or interpret data about the object's status, performance, or behavior. This suite of technologies and applications that equip devices to generate information and instant data analysis is known as Internet of Things (IoT). Conceptually, the IoT implies physical objects being able to utilize the Internet backbone to communicate data about their condition, position, or other attributes of their environment, turning any object into a source of information by using sensors and network connectivity. (Holdowsky, Mahto, Raynor, Cotteleer, 2015)

The term "Smart Building" encompasses a logical, physically proximate grouping of smart things. Adopting the definition provided by the leading consulting company Deloitte, Smart Buildings are "*Digitally connected structures that combine optimized building and operational automation with intelligent space management to enhance the user experience, increase productivity, reduce costs,*

and mitigate physical and cybersecurity risks." Within Smart Buildings, people can meet and interact with each other, exploit advanced technology to perform their functions, and benefit from a digitally enhanced experience overall (Wellener, Michalik, Ashton Manolian, James, 2018).

A Smart Building should incorporate all aspects of technology, which can be grouped into three categories: physical, digital, and services. To display and study the different layers of assets and technologies deployed, Deloitte developed a framework, figure 6, consisting of three levels:

1. The physical assets within the structure: the actual physical components that compose the smart infrastructure and that enable remote and automatic control thanks to the imbedded intelligence, such as sensors, lighting, gateways, etc.;
2. The digital assets throughout the connected space: the digital technologies proliferating into the built environment that fundamentally impact the interactions, from the IoT platform (e.g. Wi-Fi, AI, machine learning) to digital automation and Cloud storage;
3. The use cases: services enabled by the combination of physical and digital assets, tailored to meet the specific needs of the occupants (e.g. usage-based maintenance, a form of predictive maintenance triggered by the actual utilization of a physical asset).

Therefore, a Smart Building is a structure capable of capturing, managing and using data across its fully integrated system to deliver services to the building tenants who interact with it and to provide a seamless experience overall, adapting and reacting quickly to various situations.

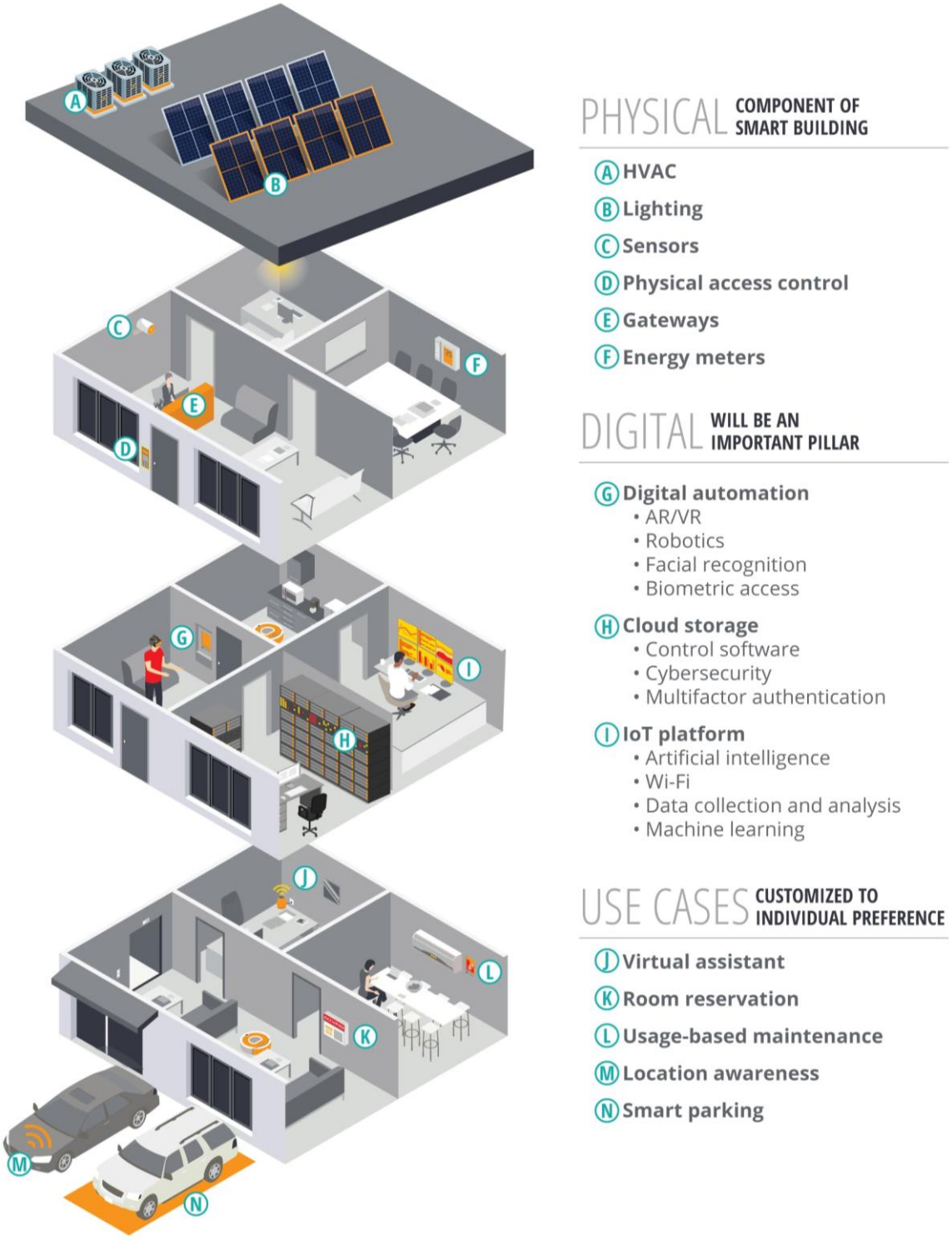

Figure 6: Deloitte's Smart Building Framework.

Empirical Settings

Smart Buildings are not limited to residential buildings: they include office buildings, factories, shopping malls, hospitals, academic campuses, stadiums, airports, military bases, and so on. Despite crossing all industries and uses, Smart Buildings can provide the same basic capabilities:

- Monitoring: sensors and external data sources enable the comprehensive monitoring of products conditions, external environment, and products operations and usage, as well as enabling alerts and notification of changes;
- Control: software embedded in products or products Cloud enables control of functions and personalization of the user experience;
- Optimization: monitoring and control capabilities enable algorithms that optimize operations and usage in order to enhance performances and allow predictive diagnostics, service, and repair;
- Autonomy: combining monitoring, control, and optimization allows for autonomous products operation, self-coordination of operations with other products and systems, autonomous enhancement and personalization, and self-diagnostics and service.

Furthermore, according to the latest research published by the Internet of Things Observatory (Osservatorio Iot, 2019), the main application areas for Smart Buildings can be classified as follows:

- **Safety** (e.g. fire detection, gas leaks, flooding, management of rescue activities);
- **Security** (e.g. intrusion detection, video surveillance, access control);
- **Energy management** (e.g. energy saving scenarios, smart meters, energy awareness);
- **Scenarios management** (e.g. smart lighting, heating monitoring and control, windows and curtains, opening/closing on the basis of the specific scenario);
- **Ambient assisted living** (e.g. support for users with physical and/or cognitive disabilities, support for frail elderly, identification of behavioral abnormalities).

Although the capabilities provided by intelligent buildings have notably improved over the past several years, not much has changed in the way in which individuals interact with the infrastructure: communication between buildings and their residents rarely extends beyond the sporadic push of a button or flip of a switch. Nevertheless, user experience is rapidly emerging as the next focus of today's Smart Building strategy, in order to enhance the ways in which tenants benefit from their surroundings. With this new perspective, the basis of value creation for owners and operators in the Smart Building sector is shifting from providing control of facilities and operations and enabling

better resource management to connecting humans with their environment and supporting ways to collaborate digitally. (Fletcher, Santhanam, Varanasi, 2018)

3.2. History and evolution of the Smart Building industry

There are some uncertainties on when the concept of Smart Building was introduced for the first time. According to Fletcher, Santhanam and Varanasi, the 1880s saw the initial foray into modern building automation, when an American professor created the first thermostat. Indeed, the first building automation wave was focused on mechanizing heating, ventilation, and air conditioning (HVAC) adjustments to maintain occupant comfort.

The second wave emerged about a century later, in the 1980s, when computers were introduced into facility management. New building infrastructures could finally be automated, including lighting, security, and safety. Consequently, building automation complexity increased and building management systems (BMS) were born to simplify controls for building operators. Moreover, basic data on facility performance was also collected, although deriving actionable insights was tough due to the absence of valid tools for data integration, interpretation, and analysis. In 1984, for instance, a New York Times article described real estate developers creating "*a new generation of buildings that almost think for themselves […] called intelligent buildings.*" Such buildings were defined as "*a marriage of two technologies – old-fashioned building management and telecommunications*." At that time, several major technology trends were under way. One was that the U.S. telecommunications industry was pursuing deregulation and several innovations entered the telecommunication market; the second major trend was the creation of the personal computer industry. This environment also produced the first real connection between real estate developers and technology, and this context presented an opportunity for building owners to resell services within their facilities and add value to their business.

In the next decade, some technological advancements in buildings – including structured cabling systems, audio visual systems, building automation controllers with direct digital control, conditioned space for network equipment, access control systems, and video surveillance, among others – led to what we call Smart Building industry today. In fact, the third automation wave started in the 2000s, which is already defined as the present state. Electricity cost reduction became a

corporate objective, and government regulations emerged as well. These savings funded the installation of enhanced BMS capable of active energy management to drive conservation building-wide.

Nevertheless, other experts fix the initial venture into Smart Buildings much later. James M. Sinopoli, in his book "*Smart Buildings Systems for Architects, Owners and Builders*", dated the origin of the discussion about Smart Buildings to the end of the 1990s:

"Smart Buildings are not just about installing and operating technology or technology advancements. Technology and the systems in buildings are simply enablers, a means to an end. The technology allows us to operate the building more efficiently; to construct the buildings in a more efficient way, to provide productive and healthy spaces for the occupants and visitors, to provide a safe environment, to provide an energy-efficient and sustainable environment, and to differentiate and improve the marketability of the building." (James M. Sinopoli, 2009).

3.2.1. Smart Building; an industry convergence

The Smart Building industry is a clear example of industry convergence. During the past years numerous factors such as globalization, deregulation, harmonization, and always shorter technological life span have radically changed the structure of different industries. In particular, an interesting aspect of these changes is the blurring and redefinition of industry boundaries, in other words, the convergence of different industries into a new one. This brought to the definition of what is an industry convergence: "*the converging of two or several hitherto separate industries"* (Weaver, 2007).

As proposed by Weaver in his paper *"Research proposal: Industry convergence – Driving forces, factors and consequences"*, there are a number of factors that drive the convergence of an industry; undoubtedly technological change and innovation are the principal ones but there are also others, including: deregulation, standards, business model innovation, changing customer requirements and industry channel structure. Clearly it would be a huge mistake thinking that industry convergence is driven only by exogenous factors, but it is also fostered by firms' actions. Examples of this are: the entrepreneurial managerial creativity that very often leads innovative technological

start-ups to push the boundaries of existing industries, or the corporate diversification strategies of big firms, that take bold strategic decisions, reshaping their business and then the industry itself.

The Smart Building industry represents a convergence in complements; this particular type of convergence, opposite to the substitutes convergence, occurs when products or services that were previously unrelated are bundled together to form a new combination and integrated class of products/services with added value for end-users. This is clear in the Smart Building industry, where products/services that were enough in the past are now coupled with additional, IT-based, ones to enhance people experience and deliver the aforementioned value propositions. Think about a security camera that not only performs its intended task, recording, but now delivers a value-added service, facial recognition and access control, through the use of an IT-based service, Artificial Intelligence. This new technology deployment is not an easy nor simple to develop. The aforementioned IoT-based solutions require integrating thousands of different products and services, belonging to different traditional industries, (connected devices, networks and clouds, data analytics, machine learning, mobile applications) with the traditional building infrastructure merging them into a seamless and stable one. *(*PwC. *"Smart Building technology deployment: A systemic approach to enhancing operational efficiency and occupant experience."* 2019)

The convergence of industries brings different effects with itself, starting from a market enlargement and an increase in competition, since the new industry is made, theoretically, by all the players belonging to the two old industries. Also, it could completely disrupt the value chain, demanding a reconfiguration, the elimination or the introduction of some parts of it. But the most interesting effect, on this research behalf, is the creation of a new context for innovation and technology management and the development of innovation strategies. (Bröring 2010)

The merge of two separated industries merges also the areas of knowledge and competences; that are assets and are industry specific, due to their cumulative nature and their path dependency. (Bröring 2010)

Then, is clear how no player, notwithstanding from which industry it comes, owns all the competences needed to innovate and perform successfully in the converged industry. Then there is the need to collaborate and create strategic alliances, joint venture and M&A.

Convergence is something that creates discontinuity with the past, that creates big uncertainties, that brings huge opportunities but also huge risks, especially in terms of technological investments and choice of business model. The uncertainties are due to the lack of preferences and technological designs, due to the young age of the market, and the lack of all the firms involved in this market of necessary competences. Therefore, companies choose to resort to partnerships and collaborations to limit the risks, but also to gain faster that knowledge and competences that they lack to offer products or services that match the new requirements of the converged industry, avoiding huge initial investments in technological research to develop long term competences.

As Bröring present in her research "*Developing innovation strategies for convergence – is 'open innovation' imperative?*", firms may be trapped in their old belonging sectors and its winning competences. Moreover, the farther the two converging industries are the higher the level of deviation from its belonging industry and its technology-related path-dependencies will be.

Consequently, companies will face severe competence gaps and may fail if choose to act as lone heroes in the market. Accordingly, the firms facing technological competence gaps need and must adopt a more open approach regarding the source of technology, knowledge and competences part of their innovation strategy and regarding the way of performing in the market.

Therefore, the farther the converged industries are, the more a firm will encounter competence gaps, then the higher will be the need to open up its innovation process and adopt Open Innovation, creating partnerships and alliances with partners from different industries bringing together complementary competencies.

"If firms really want to engage in this type of innovation, they need to open up their innovation processes and combine needed technological and market competencies from both industries." (Bröring 2010)

Then, is clear how Open Innovation is imperative to innovate and perform in an industry convergence. Open Innovation is fundamental whenever capabilities requirements change, and a firm's only capabilities are not enough anymore to successfully perform in the market. Open Innovation is the only approach that enables them to dynamically and flexibly access external complementary capabilities to integrate them and address rapidly the changed environment, and it is the only way to go that a firm has if it strives to capture the maximum value and aims at a leading position in the new market. If companies resort to a Closed Innovation strategy they have chosen not to adapt to convergence and won't perform successfully in the market.

3.3. The enabling technologies

Smart Buildings, being per definition "*Digitally connected structures that combine optimized building and operational automation with intelligent space management to enhance the user experience, increase productivity, reduce costs, and mitigate physical and cybersecurity risks*.", are all about technologies, advanced technologies. That enable fast and constant connections between people, objects and the building. Few key technologies are the foundations of the Smart Buildings, these are: Cloud computing, Big Data and data analytics, Artificial Intelligence (AI) and Internet of Things (IoT). These technologies have spread always more in the last years and are now a constant in our life. These are all interdependent and all together enables a building to be smart.

3.3.1. Cloud Computing

"Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction. This cloud model is composed of five essential characteristics, three service models, and four deployment models." (NIST definition of Cloud computing, 2011).

The five essential characteristics are the following:

- On-demand self-service: all users can independently have provision of computing capabilities (server time and network storage), without requiring any interaction with the service provider.
- Broad network access: capabilities are available on the network and can be accessed through standard mechanisms and across different platforms (smartphones, laptops, tablets).
- Resource pooling: the provider's computing resources (storage, processing, memory) are pooled to serve multiple users.
- Rapid elasticity: capabilities can be elastically provisioned and released to rapidly scale outward and inward with the demand. To the users these capabilities seem then unlimited and always appropriate in quantity.

- Measured service: cloud systems automatically control and optimize resources use, monitoring the use providing transparency to both the provider and the users.

The service models of cloud computing services are three:

- Software as a Service (SaaS): the consumers have the permission to use the provider's applications on the cloud infrastructure. The consumers don't control or manage the cloud infrastructure but only benefit from it.
- Platform as a Service (PaaS): the consumers have the permission to use the cloud infrastructure to deploy consumer-created or acquired applications. The consumers don't control or manage the cloud infrastructure but have control on the deployed applications and their application's configuration.
- Infrastructure as a Service (IaaS): the consumers have the permission to use the cloud infrastructure to deploy and arbitrary run software, operating systems and applications. The consumers don't control or manage the cloud infrastructure but have control over the operating systems, storage, deployed applications and possibly of select networking components (host firewall).

The four deployment models are:

- Private cloud: the cloud infrastructure is of exclusive use of a single organization.
- Community cloud: the cloud infrastructure is of exclusive use of a specific consumers' community.
- Public cloud: the cloud infrastructure is of open use to the general public.
- Hybrid cloud: the cloud infrastructure is a composition of two, or more, aforementioned cloud infrastructures.

Clouds infrastructures are crucial for the Smart Building environment. These avoid the need of physical database infrastructures in the building itself saving space and the up-front investment in servers and enable the continuous processing and gathering of data, available everywhere not just in site. Moreover, cloud computing allows to have lower computing capabilities and resort to cloud providers to compute the excess of data. This reducing the underutilizations and re-dimension its own computational power, reducing then the cost of having an over dimensioned infrastructure. Resorting to cloud computing providers is particularly appropriate when the demand for a service

varies with time, or when the demand is unknown in advance. (Armbrust, Fox, Griffith and others, 2010).

3.3.2. Big Data

"Big Data is the Information asset characterized by such a High Volume, Velocity and Variety to require specific Technology and Analytical Methods for its transformation into Value." (De Marco, Greco, Grimaldi, 2016). These data come from a multitude of sources; online transactions, emails, videos, audios, images, click streams, logs, posts, search queries, health records, social networking interactions, science data, sensors and mobile phones and their application. To define them is used the five Vs method; initially three, Volume, Velocity, and Variety, expanded then to five adding Variability and Veracity that completely describe their nature.

- Volume: it refers to the enormous mass of data generated through various channels (the estimated amount of data produced every day is equivalent of everyone on the planet downloading 60 Game of Thrones episodes, 20 times in a row).
- Velocity: it refers to the speed at which data can be acquired and used.
- Variety: it refers to the different types of data available from different sources.
- Variability: it refers to how the interpretation of the data can vary according to the gathered and analyzed context, since there is no well-defined structure for the data.
- Veracity: refers to the quality of the data and their reliability.

As we mentioned before there are different typologies of data that can be grouped in five big macro categories.

- Machine to machine (M2M): data generated by the interaction of electronic devices (e.g. sensors, RFID)
- People to machine (P2M): data generated by the interaction between humans and electronic devices (e.g. eCommerce data)
- People to people (P2P): data generated by the interaction between people (e.g. social networks)

- Public administration: data collected in public databases (e.g. public transportation, energy, demographic statistics)
- Enterprise data: data present in enterprises' warehouses (e.g. products, transactions)

Another distinction can be made between structured and unstructured data, the structured data are easily useable data, stored and organized in predefined database schemas, whose primary sources are the transactional systems. While unstructured data can't be adapted in a predefined schema because of their partial or not sufficient structure, such as social networks data.

Big Data alone are useless, these cannot be handled and processed easily, the big dataset and velocity are too much to handle for computers (Fisher, DeLine, Czerwinski, Drucker, 2012). To extract value from them analytical methods are needed. There are mainly four types of analytics:

- Descriptive analytics: tools that describe the present or past situation of a specific issue.
- Predictive analytics: tools that describe the present and past situation and performing data analysis are able to predict what might happen in the future
- Prescriptive analytics: tools that not only can predict what might happen in the future but, thought the data analysis, are able to propose to decision makers possible solutions.
- Automated analytics: tools that are able to independently implement the action suggested by the previous analysis.

Big Data, and especially Big Data analytics are extremely important because are at the foundations of all the enabling technologies of a Smart Building, such as Artificial Intelligence and Internet of Things.

3.3.3. Building Information Modelling

"Building Information Modelling (BIM) is a collaborative process that seeks to add value throughout the life-cycle of an asset." (British Standards Institution, BSI).

The Building Information Modelling (BIM). is an integrated process that creates, based on coordinated, reliable information, inside a common space of data sharing, the building's digital model all across its lifetime. Going from the design phase through construction till operations and day-to-day management. BIM is born from the will to create collaborations between the architects, the MEP engineers and the structural engineers, to have interoperable software and integrate the processes and the sustainability. It allows experts more easily to predict building's performances before these are built, to respond to design changes faster, to optimize designs with analysis, simulation and visualization tools, to deliver higher quality construction documentation and to extract valuable data from the model to improve decision making and fasten up the decision making process (Strafaci, 2008).

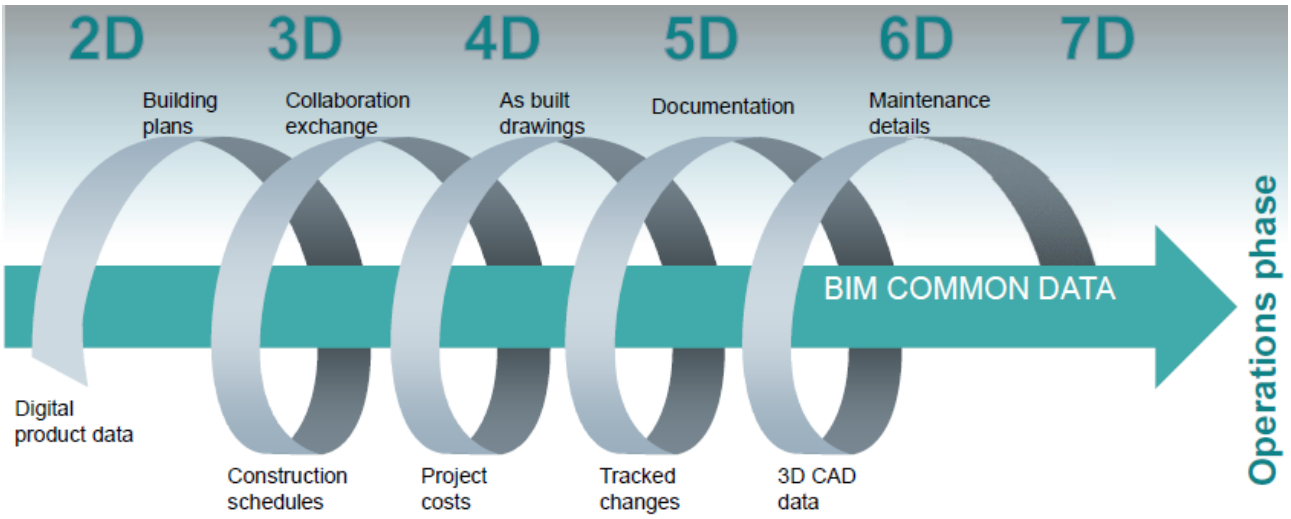

Figure 7: BIM's phases

Implementing a BIM process starts with the creation of coordinated, reliable design information about the project, such as digital product data, building plans and construction documentations. Starting to create a 3D model of the building in which all the designs are dynamically related one with the other, meaning that all the related designs of a part of the project will automatically update and adjust following a modification of an aspect of the plan. Though that the BIM facilitates the

evaluation of many design alternatives in real time providing the general overlook of the building, enabling simulations and analysis to optimize the building design, making it more efficient, sustainable or safe.

The real improvement of the BIM system is its dynamic nature, that enables continuous simulations and analysis providing real time feedbacks, this permits to find the best design solution in the very beginning of the project, reducing enormously the construction documentation and the money spent in the later phases of the project to make even minor changes (Strafaci, 2008).

The Digital Twin is the outcome of the BIM, the Building Information Modeling focuses on a building's design and construction. A Digital Twin represents how people interact with built environments. It is a digital replica of physicals entities: the building, processes, people, places, systems and devices, and all the relationships and interactions between them, that links the physical world with the virtual one. A Digital Twin can give you information about the current state of the build subsystems and how they are being impacted by occupant behaviors. Data are transmitted in a transparent way enabling to the virtual entity to exists at the same time of the physical one, and to provide data in real time, facilitating the recognition of problems, inefficiencies and possibilities of improvement. For example, it enables the real time identification of failings in the HVAC or lighting systems, or suggest solutions to improve the flow management of people in crowed period of time. Moreover, it gathers all the data about the project, facilitating the recovery of plans, designs and information from the very beginning of the building's life.

It virtually represents the physical world with a Digital Twin that models the relationships between people, places and devices, it is a model that evolves over time to deliver more value with each new stage of the building's lifecycle.

3.3.4. Artificial Intelligence

To start talking about Artificial Intelligence (AI), we must do before an excursus on what is Machine Learning (ML).

Machine Learning is one of the methodologies that provide to Artificial Intelligence its capabilities, described below, in particular Machine Learning is *«The field of study that gives computers the ability to learn without being explicitly programmed» (Arthur Samuel, 1959).* Computers won't need any more a program to provide an output, but the computer is trained, feeding it with lots of data, to provide itself the program that associates the data with the output.

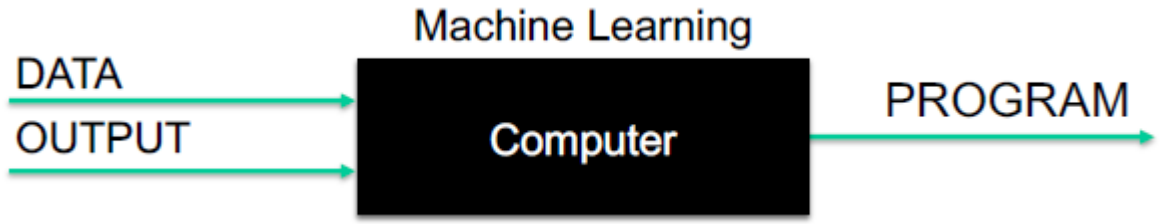

Figure 8: Machine learning process

Machine Learning is then one of the roots of Artificial Intelligence.

Instead, clarified what Machine Learning is, *"Artificial Intelligence is the branch of computer science that studies the development of hardware and software systems with specific capabilities typical of humans and able to autonomously pursue defined objectives, making decisions that were previously only made by humans."* (Artificial Intelligence Observatory, 2019). It gives the capability to computers to process natural language and images, to learn, reason and plan and to interact socially and physically. Computers, machines more in general, are enables to become autonomous decision-makers, not needing human interaction.

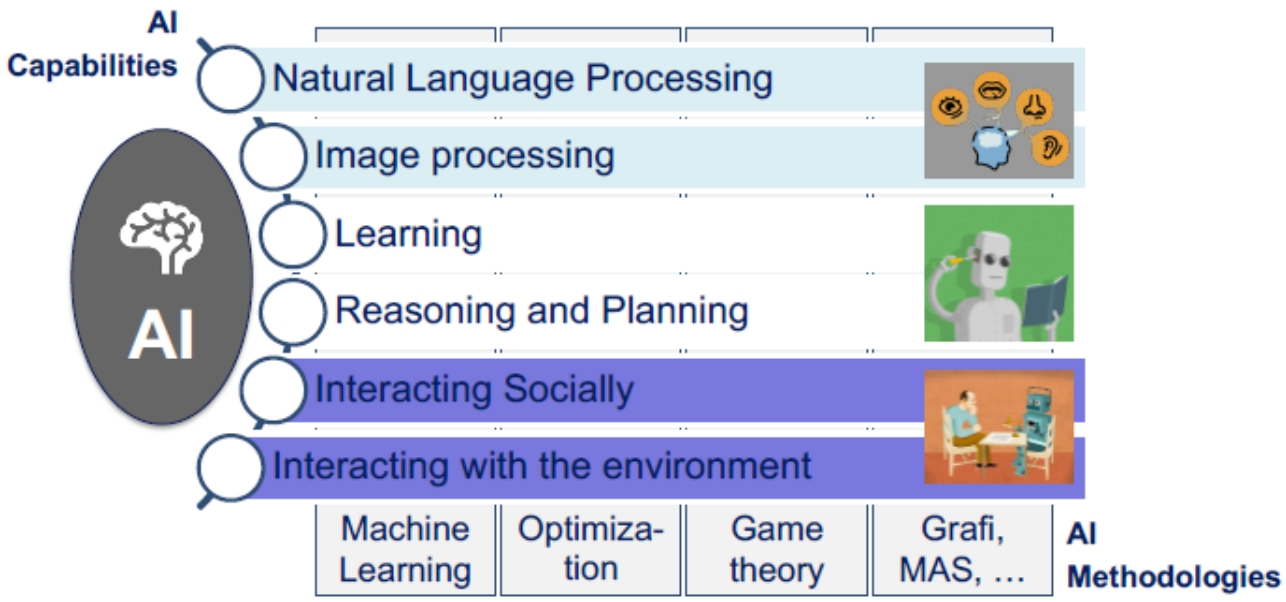

Figure 9: AI capabilities

Artificial intelligence has a numerous possible application fields, that can be group in nine big categories:

- Autonomous Vehicle: any kind of vehicle, indoor, outdoor, driving, flying, navigating, able to perceive the external environment and able to adapt to this environment (i.e. self-driving cars, drones, warehouses' machinery).
- Autonomous Robot: robots that can move themselves or some parts, manipulate objects and execute various actions, with no human intervention, understanding their surroundings and adapting to events not foreseen nor programmed (i.e. industrial and medical robots).
- Intelligent Object: objects that are able to perform actions and take decisions without human intervention, using sensors and actuators to interact with their surroundings, able to learn users' habits (i.e. security cameras, wearables).
- Virtual Assistant/Chatbot: software agents that are able to interact with people proving services or performing actions based on commands or requests (i.e. Vodefone's Tobi).
- Recommendation: solutions aimed at showing the preferences or general decisions taken by the user. Based on information provided by the user, even indirectly (i.e. Amazon's suggestions of products).

- Image Processing: solution for analyzing images and videos, to recognize people and extract information from the image. (i.e. software used in surveillance to detect possible threats).
- Language Processing: solution for content comprehension, translation, text dictation (i.e. smartphones' text dictation).
- Intelligent Data Processing: solutions that use algorithms to extract information from data and trigger consequent actions (i.e. predictive analysis, pattern discovery).

Inside the Smart Building itself the Artificial Intelligence plays a key role, in particular the roles that AI can play in this market are three. First, Machine Learning's algorithms can act inside the smart objects, in local, improving their functionalities and enabling them to elaborate data internally, without the need of the cloud. This bigger computational power provides the devises with a higher decisional independence, sending to the cloud pre-managed information reducing the amount of data to be handled, reducing consequently elaborations and storage times. Secondly, Artificial Intelligent will continuously improve the functioning and the comprehension capabilities of the vocal assistants. Lastly, the AI creates value services, such as energy management, safety and security, in-thing purchase.

3.3.5. Internet of Things

There is no common definition or understanding of what the Internet of Things actually encompass (Wortmann, Flüchter, 2015). Is possible to describe the IoT as a set of smart objects all connected between them through a smart network, that must exchange data and take actions based on those data. The characteristics of a smart object are: (i) self-awareness: it must know something about itself like identification, localization and diagnostics. (ii) interaction: capability of metering, sensing and implementing. (iii) processing: capability of elaborate and understand that something is happening. (iv) communicating: communicate to the users what is going on. The fields of applications of IoT are numerous and different one from the other. The most notable ones apart from the Smart Building, abundantly discussed before, are the following: smart home, it is an ecosystem where appliances and devices can be automatically controlled remotely from anywhere though networked devices. The application areas of IoT in particular touch: safety, security, energy management, scenario management and ambient assisted living. Smart transport, solutions that

include vehicle fleet tracking and mobile ticketing, info-mobility for traffic, emergency calling, insurance prizes bond to drivers' attitude, and self-driving cars, also bond with smart cities. Smart city, solutions like the real-time monitoring of parking space availability and intelligent lighting of streets, waste management, environmental monitoring, security, infotainment and tourist services are being explored. Smart factory, under the heading of Industry 4.0 are pushed intelligent production systems, predictive maintenance, autonomous quality control and wearables to increase workers' safety. And bond to that, smart logistics, use of heating map to improve the process, material handlings continuously monitored inside and outside the warehouses, traceability in the supply chain and last use of robots for deliveries. All this services and areas are highly interdependent and superimposable and are part of an ecosystem in which one would not have sense without the other.

The real innovation bought by the Internet of Things is the combination of the physical with the digital worlds to create new products, this results in an enchanting of the primary thing-based function by the IT-based service (Wortmann, Flüchter, 2015). In example, the primary thing-based of a lightbulb is providing light. But if it's coupled with an IoT technology, such as presence detector, it could become a low-cost security system that activates if detect intruders.

The Internet of Things is what characterizes most a Smart building, the network of different objects interconnected that monitor, process and interact with other objects or people is the foundation of the Smart Building ecosystem.

3.4. The Smart Building regulatory environment: laws, incentives and barriers

Buildings are responsible for approximately 40% of energy consumption and 36% of CO_2 emissions in the European Union, making them the single largest energy consumer in Europe. Currently, about 35% of the buildings in the EU are over 50 years old and almost 75% of the building stock is considered energy inefficient; at the same time, only 0.4 – 1.2% (depending on the country) of the building stock is renovated each year. Hence, renovation of existing buildings can lead to substantial energy savings and play a crucial role in the clean energy transition, since it could reduce the EU's total energy consumption by 5 – 6% and lower CO_2 emissions by about 5%. In addition to energy efficiency gains, a renovated building standard can also:

- Create economic, social and environmental benefits;
- Make homes more affordable and help families who struggle with energy poverty;
- Contribute to the improved health, comfort and wellbeing of their occupants by reducing respiratory illnesses and other diseases caused by a poor indoor climate.

Moreover, investments in energy efficiency boost the economy, especially the construction industry, which contributes for about 9% to Europe's GDP and is accountable for 18 million jobs. In particular, SMEs benefit from a stimulation of the renovation market, as they generate more than 70% of the value added in the EU building sector. (European Commission, 2019)

In order to boost energy performance of buildings, the EU has established a legislative framework that includes the *Energy performance of buildings directive* (2010/31/EU) and the *Energy efficiency directive* (2012/27/EU), which were both recently rewritten as part of the *Clean energy for all Europeans* compendium. Together, these directives promote policies that will help achieve a highly energy efficient and decarbonized building standard by 2050, create a stable environment for investment decisions to be made, and that will allow consumers and companies to make better informed choices to save energy and money. The *Energy performance of buildings directive* includes detailed requirements and procedures to support national governments and take stock of their progress; in particular, it requires that all new buildings must be nearly zero-energy buildings (NZEB) as of 31 December 2020. (European Commission, 2019)

Other EU initiatives aimed at incentivizing the clean energy transition are:

- The Building Stock Observatory. Established in 2016, it assesses improvements in the energy efficiency of buildings and the impact of this on the actual energy consumption of the buildings sector overall, providing the European Commission, policymakers, investors, stakeholders, local and national authorities and researchers with comprehensive knowledge on Europe's building standard; it contains a database, a data mapper and factsheets for monitoring, and statistics on the energy performance of buildings across Europe. (European Commission, 2019)
- Long-term renovation strategies. Since 2014, EU countries must submit long-term renovation strategies that boost investments in the renovation of residential and commercial buildings, along with a roadmap and underpinned by a solid financial component; as of 2019, these strategies play a crucial role in the integrated National Energy and Climate Plans of each country. (European Commission, 2019)
- Financing renovations. EU countries can set up support mechanisms to help finance renovations that make buildings energy efficient: under the *Energy performance of buildings directive*, EU countries can provide a list of national measures for funding opportunities, that are updated every three years and can be found in the national energy efficiency action plans. Examples pertaining to the Italian regulatory environment, further explored in paragraph 3.5.2, are the *Iper* and *Super Amortization*: to support and incentivize businesses investing in new technological assets, functional to the digital transformation of their internal processes, the Minister of Economic Development grants an overvaluation of 250% and 130% respectively for physical assets purchased or leased. (Ministero dello Sviluppo Economico, 2019)
- Certificates and inspections. Energy performance certificates provide consumers with information on the buildings they plan to purchase or rent, including an overall rating and recommendations for cost-effective improvements; under the *Energy performance of buildings directive*, all EU countries have established independent control systems for energy performance certificates and inspection reports for HVAC systems. Furthermore, the EPBD requires the development of a voluntary European scheme for rating the smart readiness of buildings, the "Smart Readiness Indicator" (SRI); it is meant to raise awareness about the benefits of smart technologies and ICT in buildings from an energy perspective, encourage

consumers to invest in Smart Building technologies, and support the uptake of innovation in the building sector. (European Commission, 2019)

3.4.1. The Smart Readiness Indicator

One of the main points of the amendment proposed by the EPBD is to make the most of the previously described smart technologies: in fact, the spread of information technology in the construction sector allows for a considerable reduction of energy consumption and greenhouse gases emissions, as well as a better interaction between buildings and other components of the energy system.

It is estimated that the introduction of these intelligent technologies will favor the interoperability of buildings with electricity grids, district heating networks and mobility infrastructures and the optimization of communication, control and transmission of data and signals, facilitating the introduction of new operators in the energy market: the so-called "demand aggregators". This new type of organization aims to help facilitate the flexibility in energy provision and consumption during peak times. The idea behind it is not new: national grids often pay large energy users like steel works to reduce their energy demands during peak times, but now smart grid technology and smart metering systems allow the aggregator firms that have recently emerged to offer this service to medium sized firms that wouldn't otherwise be able to deal directly with national grids. Aggregators can thus turn on generators or turn off lighting and AC systems at a moment's notice, upon receiving the information that the national electricity system is highly congested, and get paid a fee for helping to balance the grid. This means that there could be a general shift over time from a production-driven energy system to a consumer-driven one, which would better suit viable energy sources like renewables. Furthermore, besides enabling significant energy and economic savings, the extensive use of smart technologies could substantially improve user comfort, adapting building management to the needs of the tenants.

Therefore, in the definition of technical systems for the building (Article 2), the EPBD introduces automation and control systems as technologies and services that contribute to the safe, economical and efficient operation of the same systems, while stating (Article 8) that by 31 December 2019 the European Commission must adopt a delegated act establishing an optional

European shared system to evaluate the “smart readiness” of buildings (i.e. the ability to adapt their own functioning to the needs of both the occupant and the network, and to improve energy efficiency and overall performance). In particular, the system will define a new indicator of the building's predisposition to intelligence (Smart Readiness Indicator, SRI) and a formal methodology to compute it. By the same date, the Commission will specify the technical methods and timing for the implementation of the new, non-binding indicator in member states and will clarify the complementarity of the indicator with respect to the set of energy performance certificates.

3.4.2. The Italian regulatory environment for Smart Buildings

The building sector is responsible for the biggest share of total energy demand (37.1%) in Italy. Decree 192/20051 set the basis for the EPBD implementation in Italy. It was followed by a number of complementary legal acts updating the minimum requirements for buildings, building components and technical building systems, while extending the calculation to cooling and lighting systems and providing guidelines for energy performance certification (2009) and defining requirements for assessors as well as specifications for the inspection of technical building systems (2013). (Costanzo, Martino, Varalda, Antinucci, Federici, 2017)

Law 90/20133 implemented Directive 2010/31/EU, introducing significant changes to the first implementation. Following Law 90/2013, three ministerial decrees, signed on 26 June 2015, completed the implementation of Directive 2010/31/EU, providing:

- An updated energy performance calculation methodology, rules for taking into account the use of renewable energy sources in buildings and the system boundary;
- New stricter minimum energy performance requirements for buildings (and major renovations) and technical building systems and components since 1 October 2015; the following energy services are taken into consideration: heating, cooling, domestic hot water and ventilation for residential buildings, lighting and internal transports (lifts, escalators) for non-residential buildings;
- New conversion factors of delivered energy into primary energy (the current overall energy performance of new buildings varies with typology and climatic zone);

- A new NZEB definition (the target for NZEB progress is that from 2019 all major renovated public buildings and from 2021 all remaining major renovated buildings shall be NZEB);
- A new national Energy Performance Contract (EPC) scheme and guidelines.

Provisions for securing compliance to minimum requirements in new and renovated buildings were provided. Best practice in EPBD implementation in the period 2015-2016 reside in the inspection of technical building systems, extended to cooling systems, that also resulted in improved maintenance, security and employment, and in the wider use of databases (both EPC and inspections) in some regions, integrated at the national level by the establishment of a new national EPC-technical building system centralized database (although regions are still in charge of managing their own databases and for related monitoring and control).

The building renovation rate is still below the potential level; a wide range of financing mechanisms are, however, in place and are being continuously strengthened. Owing to the lack of awareness and resources for renovating to the NZEB level, a stronger effort is needed which also involves the research and academic world. In respect to central public buildings, a complex program stimulating renovation uptake and monitoring and improving awareness is ongoing.

The display of the EPC in public buildings and the control of commercial EPC advertising from regions and local authorities are currently low priority and need better direction. Different communication campaigns are in place and further initiatives are under preparation. (Ministero dello Sviluppo Economico, 2015)

As of today, this far-sighted measure has been still quite disregarded, unfortunately, due to the tendency to circumvent or bend the law by all parties involved, from individual architects to entire ventures and the Public Administration itself, and it is thus only starting to show the very first results. As the regulatory outlook for different Smart Building energy technologies varies by country, companies need to watch developments closely and act on opportunities as they present themselves. Overall, consumers show a positive attitude towards saving energy, according to the market research which will be further detailed in the next chapters. However, for most of them, the lower cost of utilities is the only tangible benefit that stems from the reduction of energy consumption; therefore, the investment in the new technological assets required to implement smart solutions is often perceived as too high and not worth it. Moreover, while the cost of ICT – both hardware and software – decreases steadily and the availability of technology surges, change

itself still represents an obstacle for both individuals and businesses, which hampers an objective evaluation of the intangible benefits related to smart technologies.

CHAPTER 4: OBJECTIVES AND METHODOLOGY

This chapter wants to clarify the methodology that has been used in the data gathering and in the analysis. An empirical investigation process has been used, enabling to build a theory though case studies and real empirical data. The process resulted in a continuous comparison of the data obtained from interviews to find, and verify, patterns of relationships and commonalities, supporting this with three notable case studies that clearly showed the collaborative aspect of the industry and the partnerships that players undertake to perform in it.
In the following paragraphs a recap of the research question is provided in the very beginning. Then, the methodology through which data were gathered and analyzed is deeply explained. All the players classes are defined and described. Lastly the framework described by the questionnaire is defined and each part is analyzed.

4.1 Objectives and research question

Literature has deeply analyzed the Open Innovation model and all its faceting, but lacks a clear definition and taxonomy of its adoption inside a new converging industry, the Smart Building industry. How the principals players belonging to different traditional sectors interact and which kind of partnership and collaborations do they create to reduce the risks, to access the needed knowledge or technologies and to perform at best in this new converging industry. In this thesis, I try to answer to this question by conducting an exploratory, qualitative empirical analysis in the Smart Building industry.

4.2 Instruments and methodology

This thesis work started with the identification of the typologies of players that act in the Smart Building industry; the creation of a firms database started from these companies that were the main sponsors or simply participants to important conferences such as "*Smart Building Expo"* and *"Milano Smart City Conference".* These gave us a consistent starting point. To enlarge the database we looked first for competitors, of the already present firms, then, for partners, suppliers, complementors and substitutes to have the broadest view possible, and not miss neither one possible segment of the value chain that provides Smart Building's solutions.

We choose, for the collection of empirical evidence, to use personal direct semi-structured interviews with key informants. In fact, interviewing key informants is a very rich source of data that provides multiple views on the same topic and reduce potential personal bias.

So, parallel to the database creation, the creation of a semi-structured questionnaire, that would have been the support used to held interviews, started. It covered many aspects of the firms' business and it was as general as possible in order to not constrain answers to predefined schemes but to grasp the real ideas and business' aspects of the interviewed, to do so, open-ended questions were preferred, a deeper explanation of the parts of the questionnaire is give in paragraph 4.4.

Once identified all the companies involved in the value chain of the initial ones the selection phase started. Each single company has been analyzed to see if they actually were providers of products/services/solutions belonging to the Smart Building industry or not. This phase ended with the creation of the final database that recognized eight big clusters that grouped all the 257 different companies identified, a deeper explanation is given in the paragraph 4.3.

Once defined the actors and the classification set the next step was enriching the database with contacts. For each company of the set the right person to talk to, and its contacts, were identified, this could have been the head of the Smart Building/City business unit, if the company had one, managers belonging to marketing and sales, or to the strategic part of the firm. In certain cases, also the CEOs or the founders were involved, especially if the company was small or a start-up. Having filled all the blanks in the database we started requesting interviews with them. Many contacts refused or didn't respond to the request but at the end a pool of 51 interviews was held.

So, all the data, in this research, used for the analysis of the typologies of collaborations come from these 51 interviews held with managers of different types of companies that are currently working in the smart building environment.

The data gathered with the survey aid were appreciable and exhaustive in the whole majority of cases but needed a more structured shape. Therefore, these have been rearranged in a set of reports that structured and standardized the data into a common structure and that also provided short descriptions of the company interviewed.

These reports were the foundation for the final database; an even more structured one where the data weren't constrained anymore by the open-ended questions structures but rearranged and grouped to show at best the possible correlations and facilitate their analysis.

The methodology used for the data analysis chosen is the "Case Study Methodology"; this was chosen due to the phenomenon-driven objective and the current theoretical knowledge on the subject, in particular the lack of an existing theory that offered a feasible answer.

Eisenhardt and Graebner in their work *"Theory building from cases: opportunities and challenges"* described deeply this particular technique. It enables to build theory from case studies, it involves the use of one or more case studies to create theoretical constructs and theories based on cases and empirical evidence. The cases are the basis of the development of a theory that is formulated inductively. This method makes the theory emerge from case studies, meaning that the relationships' patterns recognized within the case and between cases help creating a theory that provides a general interpretation of the phenomenon. The replication logic is the foundation of this reasoning, each single case represents a different experiment which results confirm or disconfirm the building theory.

Since this theory-building approach is deeply rooted in many empirical data and cases the method has high possibilities of producing theories that are accurate, interesting and easily testable. Theory-building research using cases is a powerful tool to answer to the questions "how" and "why" in unexplored research areas. Lately this method has increased always more its importance, because it's one of the best ways to bond the deductive research to rich qualitative data. (Eisenhardt and Graebner, 2007)

Chosen the methodology for the data analysis it came per se the use of a multiple-case study research, since this provides, compared to the single-case study, more robust empirical basis for identifying insightful and recurring relations. The advantage of the multiple-case study is that compares more than one case and, following the replication logic, gives more precise results. Avoiding the doubt that an emerging relationship is distinctive of just an individual case, seeing it recurring in several cases, and this represents an obvious advantage with respect to the

methodology based on a single case study. Comes obvious how the higher the number of case studies, so a multiple-case study approach, the more robust the theories will be. Since the raising thesis are deeply rooted in several empirical information, theories generated from multiple case studies are generally deemed more robust, more generalizable and verifiable.

This higher likeness of resulting in better theories due to the higher number of accounted cases resort in a more complicated theoretical samplings of cases. (Eisenhardt and Graebner, 2007)

Nevertheless, the single case study, is not a completely useless approach. In fact, although is considered not the best fitting methodology for this research purpose, is an extremely useful tool to provide very detailed description of a phenomenon that doesn't find theoretical explanation in the literature.

A possible challenge of this approach concerns case selections; it's common understanding how, when cases are taken into consideration, these should be representative of the considered population. This is not true in this particular event. Because cases should be representative when the purpose of the research is to test something, and this method aims at developing a theory not testing it. The cases are selected through a theoretical sampling, that means selecting those cases that are particularly suitable for illuminating and reinforcing relationships and findings among hypothesis, and that have a high likelihood of confirm these or provide different theoretical insights that move forward the elaboration of the emergent theory, such as contrary replications of findings or elimination of alternative explanations. (Eisenhardt and Graebner, 2007)

As regards the first theory building step, case studies can lodge a wide variety of information sources including interviews, archival data, published records, survey data, ethnographies and observations. Interviews, for example, are highly efficient to gather quality empirical data, especially if the observing phenomenon is not stable in time but bond to episodes. But also expose us to the "knee-jerk" effect of having data that are biased and strongly effected by interviewees' ideas and feelings. To solve this problem a wide set of data is needed, coming from different interviewees that have different perspectives on the topic. (Eisenhardt and Graebner, 2007)

4.3 Players classification

At the very beginning of our research, we have selected and grouped the different types of players into eight big clusters:

- ESCOs: energy service companies, firms whose core business is the provision of energy services and solutions. Such as designs and implementation of energy savings projects, energy conservation, power generation and energy supply.
- General contractors: companies that manage the edification or renewal of a building. Manage the day-to-day activities of the construction site, the vendors and trades, and the communication of information to all the involved parties throughout the course of the project.
- Plant engineering studios: companies specialized in the design and installation of the electrical/data communications wiring systems, heating systems, monitoring systems (BMS) and systems' automation systems (i.e. lighting, conditioning).
- Technology providers: companies that have as core business the provision of technological products/services.
- Utilities: companies whose core business is the provision of electricity, gas, water, or sewerage.
- Facilities management: companies whose core business is the maintenance and management of buildings and equipment.
- TELCO: telecommunication companies, providers of telecommunications services, such as telephony and data communications.
- Software provider: companies whose core business is the provision of software.

A better description of all the companies interview during the data gathering process is given in the registry tables present in the annex.

4.4 Analysis Framework

The interviews, held by telephone or face-to-face, were supported by a questionnaire containing a series of questions regarding four big topics (the whole questionnaire is provided in the annex). These were aimed to deeply understand every single aspect of the firms involved. How different kind of companies tend to act to fully exploit the potentialities opened by this new type of integrated building, they offerings, their strategies and their understandings, ideas and foresight for the future. Moreover, this methodology was preferred because it provides fresh information coming from the very actors of the market, not digested and totally free by academic schemes.

4.4.1 General Data

This part aimed to grasp the overall understanding and prospects about the Smart Building market of the interviewed company. Investigating the dimension of the interviewed company's business attributable to products/services/solutions for Smart Buildings. Which are their market segments. How they are organized to provide their solutions on the market and how many people are involved in the process. The interviewed perception of the overall Italian market, its development perspectives and the development perspectives of the company itself in the Smart Building industry.

4.4.2 Business Model

A business model is a comprehensive set of strategic decisions defining the way a company creates value, transfer value to its customers and captures value. One of the best and most used way of representing the business model is the Business Model Canvas, that the table 7 presents clearly. The Business Model Canvas is a tool that helps in completely describing a firm's business model, through a set of nine building blocks, that can be clustered in the three aims of the business model.

- The value creation cluster represent how the company creates the value, in which way and to whom its products/services are made for. It includes as building blocks, value proposition, customer segments, customer relationships and channels.

- The value capture cluster shows clearly how the firm captures the created value, how it can benefit from it. Contains the key partners, key resources and key activities building blocks.

- Last, the transfer of value represents the economic model of the company. In which way it gains profits from its products/services. It includes the cost structure and the revenues steam building blocks.

Key Partners	Key Activities	Value Proposition	Customer Relationships	Customer Segments
Who are our key partners? Who are our key suppliers? Which key resources are we acquiring from partners? Which key activities do parters perform?	What key activities do our value proposition requires? Our distribution channels? Customer relationships? Revenue stream?	What value do we deliver to the customers? Which one of our customer's problems are we helping to solve? What boundles of products and servicies are we offering to each customer segment? Which costomer needs are we satisfing?	What type of relationships does each of our customer segments expect us to estabilish with them? Which ones have we estabilished? How are they integrated with the rest of our BM?	For whom are we creating value? Who are our most important customers?
	Key Resources What key resources do our value propositions require? Our distribution channels? Customer relationships?		Channels Through which channels do our customer segments want to be reached? How are we reaching them now? How are our channels integrated Which ones are the best?	
Cost structure What are the most important costs inherent in our business model? Which key resources are most expensive? Which activites are most expensive?			Revenue Streams For what value are our customers really willing to pay? For what do they currently pay? How are they currently paying? How would they prefer to pay? How much does each revenue stream contribute to overall revenues?	

Table 7: Business Model Canvas

4.4.3 Investments and Strategy

Paragraph that describes the company's strategy in the Smart Building world. It regards information about the duration and the breadth, national/international, of the firm presence in the market. The investments needed to reach their current position and the prospect investments to increase or strength the presence in the market. Moreover, the growth of the company in the Smart Building market was addressed, if it has been organic or through strategic partnerships. Identifying the partner's typology which whom the interviewed had undertaken some partnerships, and if in the future there will be different ones or not.

4.4.4 Regulations

The last part wanted to understand if firms are aware of the Italian regulations about the Smart Building industry itself but also of these norms, incentives or constrains that in some ways have helped the development of the Smart Building market, but were not made for it, i.e. the energy reclassification. Also, if they think that these are enough and will have a significant impact in the next years or not, and if there are some "good practitioners", in terms of regulations, abroad towards which Italy should look to as examples.

CHAPTER 5: ANALYSIS FINDINGS

Resorting to partnerships and collaborations is a founding principle of the Open Innovation approach. The use of alliances to access knowledge, technologies or different market areas represent one of the best examples of how the Open Innovation approach pushes to look outside the firm boundaries to find new opportunities. At the same time the need and creation of strategic alliances, joint venture and M&A is one effect of the convergence of industries. Convergence is something that creates discontinuity with the past, that creates big uncertainties, that brings huge opportunities but also huge risks. Therefore, companies choose to resort to partnerships and collaborations to limit the risks, but also to gain faster that knowledge that they lack to offer products or services that match the new requirements of the converged industry, avoiding huge initial investments in technological research. As presented in the previous chapters, the Smart Building one is an industry where the interests and offerings of companies coming from different traditional sectors converge, therefore they must also rely to external players, competitors in the traditional core business or not, looking outside their perimeters.

This research tries to show and explain the reasons behind, conducting an exploratory, qualitative empirical analysis in the Smart Building industry, and with whom the main players belonging to different traditional sectors interact, to perform at best in this new converging industry.

5.1. Smart Building Industry Analysis

The interviews held with the players mentioned in Chapter 4 provided for the whole majority high explicative quality data to work with. Despite that, the lack of a consistent amount of data or their incompleteness forced me to not describe in depth the partnerships' typologies created by the players belonging to some clusters. In particular, in the analysis it was preferred to not deep analyze the "General Contractor" and "TELCO" clusters but to use the data coming from these players for

the general analysis of the reasons that stand behind the resorting to partnerships in the Smart Building industry, held in the paragraph 5.2.

From the empirical analysis has come out that the whole majority of companies resort to more than one partnership. That they interact with different actors at the same time and create bonding for different purposes, this is clearly shown by the 80 overall alliances counted, respect to the 51 interviewees. Then all the percentages presented in the following sections are made considering the number of the registered partnerships in the cluster divided by the number of interviewed companies. Due to the tendency of firms to, most of the time, resort to more than one partnership, if all the percentages are summed the total is higher than one hundred. This choice was made to give a clearer idea of the undertook partnerships in the cluster, showing the main trends inside these.

In the following paragraphs the clusters are deeply analyzed and for each of them is shown which are the most common resorted partnerships.

5.1.1. Technology Providers Partnerships

The set of companies belonging to this group represent the more numerous one, data were gathered from 21 different firms, that resulted into 42 undertook partnerships with different types of firms belonging to different industries, creating nine different sub-categories, below described.

Technology providers and:

- Software providers.

  The most resorted set to partner with; eleven, the 52.4% of firms in the cluster undertook this, listed alliances. This type of collaboration is very common and very recursive, as shown also in the cases study hereafter provided. The reasons behind this are the need of a strong relationship between the IT based services, such as Cloud services or AI, and the more traditional products, such as lights or conditioning systems, and the lack from both sides of enough competences to integrate the two worlds alone. These relationships provide to the resorting parties the access to complementary lacking resources, and access to missing knowledge and specific technologies. Most of the times the two players interact from the very beginning of the creation of a Smart Building project, since the aim of these partnerships

is the co-development of the offer, that gives to the customers a seamless experience of a continuum between the digital and physical worlds.

- Vendors and installers.

  Represent the second category for resorted numbers, nine listed alliances, the 42.9% of the set recourse to this. This kind of relation is completely different from the previous one. In fact, technology provides use this alliance to commercialize their products and to reach and get in contacts with customers otherwise unreachable or of difficult reaching. This alliance is used mostly to reach the mass market for small plants and buildings, and to install the property products, not in big, complicated new projects where the presence of the selling company is crucial but where installers and DIY is facilitated by the smallness of the projects.

- Technology providers.

  Surprisingly the collaboration with competitors gains the podium with seven alliances, the 33.3% of the set. Since the companies that belong to the technology providers set are very numerous and have a very wide products' portfolio is pretty common to find partnerships between two competitors that provide to the same customer different technologies integrated between them. For example, a big incumbent with a small very specialized firm, or two big incumbents that focus themselves on the provision of different technologies, Chorus Life and The Edge cases. The co-development of the offer and the access to complementary technologies are the reasons that power these partnerships.

- Utilities.

  With three listed partnerships, the 14.3%, the cooperation between these two players is not so recurrent but is extremely important, especially in the understandings of the consumptions at needs and the energy trading enabled by the Smart Buildings, the possibility to provide electricity that is enough to power the building avoiding waste and the possibility to receive it from them when not needed. Moreover, we can find clear examples of these when the Smart Building concept is seen in a broader perspective and is understood in the wider Smart City concept, as described in the Aspern Seestadt case study. Again, this kind of alliance is an example of how there is a co-development of the offer and a research of a

strong integration between complementary technologies and services in the Smart Building industry.

- Plant engineering studios.

  This alliance represents the 14.3% of the set, with three appearances, too. The technology providers have different aims. On one side the need and wiliness to expand the market using this players as specialized installers to commercialize the property products and reach several markets segments but also trying to deeply integrate their technologies with the various systems needed in the building (wiring, heating, monitoring, automation systems), and then set standards. Creating, both directly and indirectly, an ecosystem that favors the use of their technologies instead of the competitors' one, because more integrated or more suitable for integration with the cabling systems.

- System integrators.

  The 14.3% of the partnerships, three listed, again, is represented by these. These represent a notable percentage of the total but not as important as the commercialization aimed one. Their purpose is mainly the access to market segments difficulty reachable otherwise, the resorting company prefers to rely on the partner for the integration of their technologies with others and all the systems needed in the building. Helping the commercialization of the products and saving resources for their installation, creating, at the same time, a trust chain that could improve their position in the market as leading company, setting standards and increasing the trust of this category in them and their products.

- Start-ups and small innovative companies.

  This very interesting type of alliance, that counts for the 14.3% of the set, is maybe one of the best and most clear representation of the Open Innovation paradigm. How companies gain the access to new, complementary technologies and knowledge and how, in the whole majority of cases, they acquire the company or the technology. This is a very safe and fast way to reach out new technologies, codeveloping offers or services, or simply gaining their property right to integrate them in their offer.

- General contractors.

  Representing the 9.5% of the set with two listed partnerships, these alliances are a clear example of both the aim of standards creation and the need of a codeveloped offer since the very beginning of the projects. On one side these could be explained as the use of general contractors as installers and systems integrators at the same time from technology providers. That exploit these partnerships to increase their market presence and put the roots to become the leaders in the industry. On the other side, the highly specificity and integration needed by the Smart Building projects crave an early cooperation and creation of a codeveloped offer since the very beginning of the creation of the project; in this way a deep integration of technologies is assured and the buildings gain from that.

- ESCOs.

  With just one listed partnership, representing the 4.8% of the set, this kind of alliance is not so common in this set. This type of partnership is aimed at accessing to complementary technologies and co-develop an offer that fits the strict energy requirements of the industry.

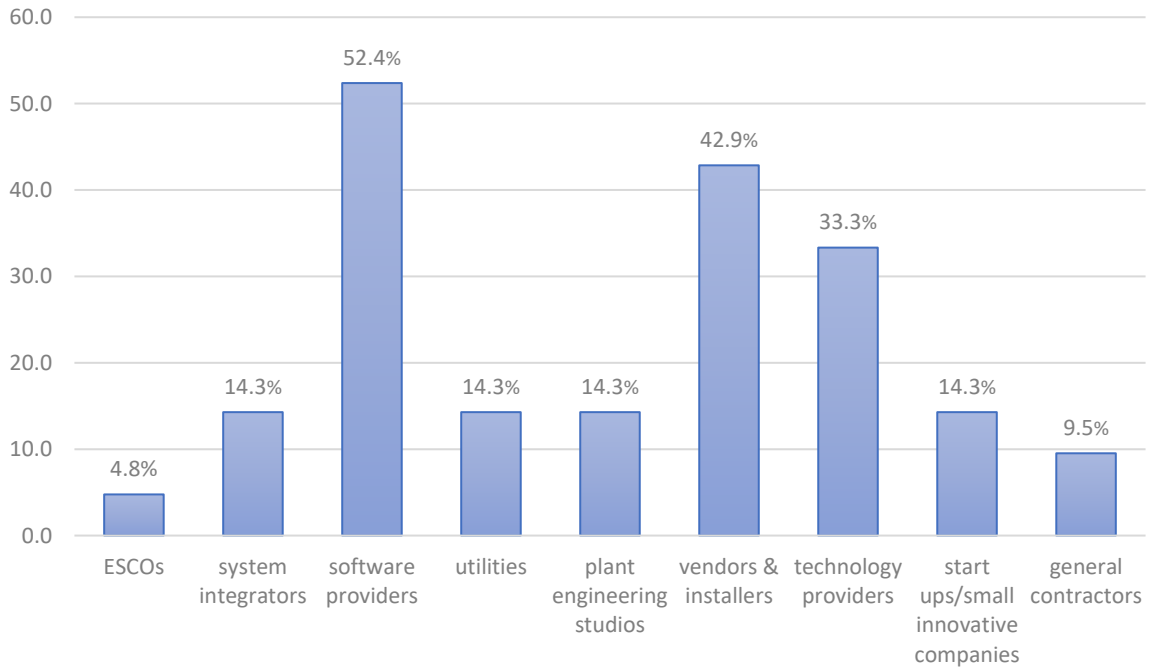

Figure 10: Technology providers' alliances

This cluster is characterized by two big trends, the alliances made with the software providers and the one with vendors & installers. These two represent two big purposes of resorting into partnerships: with the first one technology providers aim at improving their offer integrating new technologies and knowledge in their owned ones, creating an improved new ecosystem that leverages on the best capabilities of the two companies. This purpose is also the driving aim in the pursue of alliances with ESCOs, utilities, other technology providers and start-ups. The access to knowledge and competences not available inside the firm boundaries, to gain further knowledge and being able to create the best experience for customers. On the other hand, the latter partnership typology, the one with vendors and installers, is solely aimed at the commercialization and installations of their products with no aim of offer's co-development, but to gain market share and increase brand knowledge, aiming at standard setting and to improve a company's position in the market. The partnerships made with the systems integrators, the plant engineering studios and the general contractors can also enter in this latter aim but are more inclined to also looking for an improvement of the current offer of technology providers by integrating new functionalities and improving the existing one trough the partners' competences. Aiming at last to provide the best ecosystem possible with the most seamless experience to customers.

5.1.2. ESCos Partnerships

The set of companies belonging to this group represent the second for interviews number, 8. With an overall number of undertook partnerships equal to 10; clustered in four different sub-categories, below described.

ESCos and:

- Technology providers.

  With three listed alliances, the 37.5% of the set, represents the first of the two leading alliances typology to which the cluster resorts to. These partnerships, also seen in the technology providers set but with a lower recurrence, are easily explainable identifying their aims in the access to complementary technologies. The need that ESCos have of a technological partner to codevelop their offers integrating their energy services with the partners' energy related technologies (HVAC systems, lighting), is fundamental to create the most fluid and easy to use environment.

- Installers.

  Also characterized by the 37.5% with three alliances, these have a completely different purpose. ESCos rely on these to commercialize their products and install them, saving time and resources outsourcing these operations. In this way the companies can avoid investing resources to create a property retails' sales and installing forces, resorting to professionals that can reach better the whole market and are specialized in systems installations. As in the technology providers case, these type of installation and commercialization is fit to reach the mass market, characterized by small projects, while for big, high investment requiring projects the companies resort to other alliances.

- Software providers.

  The 25% is represent by the two alliances of this set. The reasons behind these are very similar to the technology providers sub-categories. In fact, ESCos look for new competences with the final purpose of integrating IT technologies in their products and services to give them the possibility of being remote monitored and accessible. This is one of the most relevant partnership's types because of the deep integration of the two companies in the creation of an integrated product/service.

- Plant engineering studios.

  Two partnerships, representing the 25% of the whole made this category. The willingness of ESCos to partner with plant engineering studios is created by the need of a deep integration of the systems of the two companies and the ESCos' need of having all the energy related products cabled and integrated with their services and systems, to give the customers the best services possible. Moreover, this relationship can increase the awareness of the ESCo in the market strengthening the trust of the two partners and leading to an increase in market shares led by the resorting to the same partners from the plant engineering studio side in future projects, exploiting at the same time the partners as specialized installers.

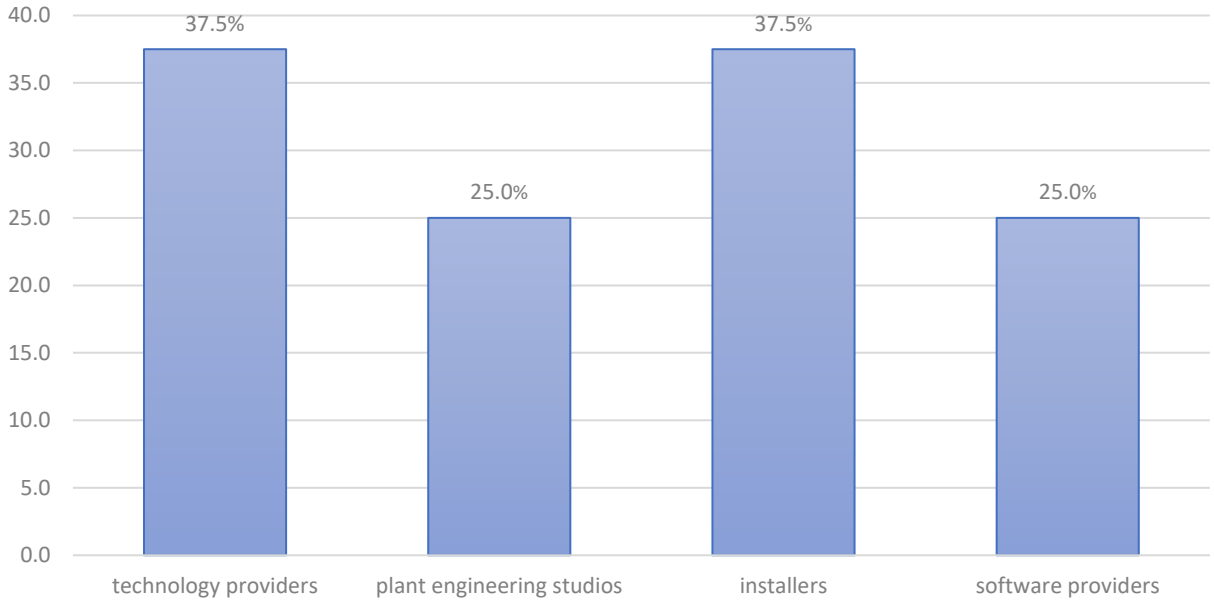

Figure 11: ESCos' alliances

Is clearly showed in the figure 11 how this cluster is very homogeneous in the partnerships' creation. Just four sub-categories where all the eight players are almost equally distributed. Two of them are characterized by a strong integration of knowledges and competences purposes, the one with software providers and technology providers. One has merely purposes bond to the installations of the products and their commercialization, the installer one. While the fourth one, the one with the plant engineering studios, is somehow hybrid and on one side include the need of a deep integration of systems in the building, and so a co-development of the offer somehow, on the other side is indirectly bond to raising the knowledge of the company in the market and the installation of products.

5.1.3. Software Providers Partnerships

This cluster is embodied by six companies that form eleven alliances grouped in four sub-categories here described.
Software providers and:

- Technology providers.
  First sub-category with five alliances, the 83.3% of the set. This type of partnership, already seen as very strong in the technology providers cluster is here strengthen by these data. The needs of technology providers of integrating their competences with strong IT ones is here tipped over. The data clearly show how the needs are mutual and the software providers need the partners' technologies, to integrate the two worlds and create the new Smart Building environment. These relationships provide to the resorting parties the access to complementary lacking resources, and access to missing knowledge and specific technologies. As shown in the case studies, Chorus Life and The Edge, most of the times the two players interact from the very beginning of the creation of a Smart Building project, since the aim of these partnerships is the co-development of the offer, that gives to the customers a seamless experience of a continuum between the digital and physical worlds.

- Software providers.
  Second for number of resorted partnerships of the set, four, the 66.7% of the total, there is the alliance with competitors. Similar to the technology providers cluster relying on competitors is very common also in this cluster. This because the two players are both software providers but are specialized in different fields, being the software world very wide, as the technological one. For example, a firm deeply specialized in cloud services, like Microsoft, that partner with another company specialized in software for the office management, like Mapiq. The strong integration of two companies belonging to this cluster is aimed at the co-development of a specific customized services and software that can at best fits the requirements of very specific projects.

- Utilities.

  Just one recorded partnership, the 16.7% of the cluster. The alliance can be seen as a way to access the market focusing on a specific player's typology, creating software ad hoc to fits at bests the partner needs, using this as starting block to enter in the market, and, only after some time ,starting creating partnerships with other players, preferred by more structured and strong incumbents in the software industry.

- Facility mangers.

  Once again only one listed alliance, again the 16.7% of the cluster. The partnership could be understood as the specialization of a software provider's company in a specific type of software that best fits the needs of facility managers. For example, the development of a particular building management system, BMS, or building information modelling, BIM, for a specific buildings' complex.

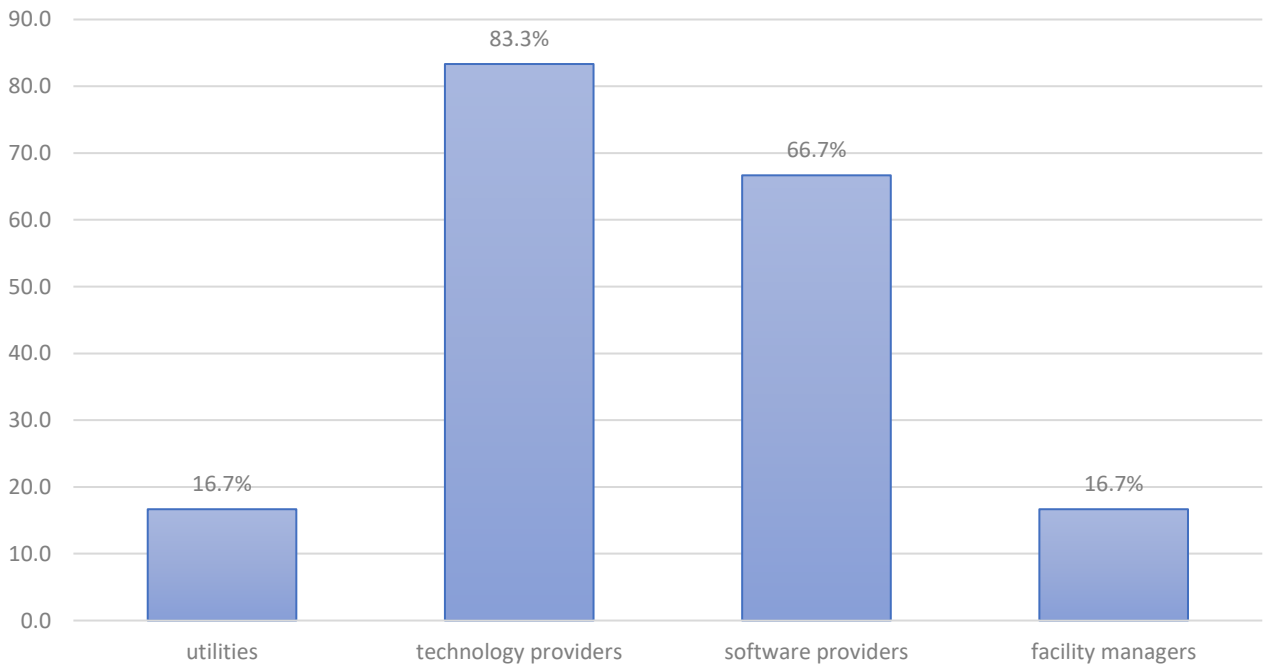

Figure 12: Software providers' alliances

As is clearly shown in the figure 12, the software providers cluster is characterized, almost in its completeness by alliances with either technology or software providers. This on the line of the search of complementary competences and knowledges to integrate those and co-create a new shared offer that include different contributes coming from many firms. A small percentage is occupied by partnerships with utilities and facility managers, always with the purpose of co-creating a shared offer, the first can be also seen as an approach to the market, targeting a specific player that is not as researched as the others by huge incumbents.

5.1.4. Plant Engineering Studios Partnerships

The data for this cluster were gathered from six different firms, that resulted into six undertook partnerships with different types of firms belonging to different industries, creating two different sub-categories, below described.
Plant engineering studios and:

- Technology providers.
  First position for number of recorded partnerships, four, the 66.7%. These alliances found also in the technology providers cluster, have as aims the integration of the various systems needed in the building (wiring, heating, monitoring, automation systems) with different technologies not available inside the studio. The access to lacking technologies to create a complete fully integrated smart ecosystem is the main goal of the partnership.
- General contractors.
  Only two partnerships, the 33.3%. Similar to the technology providers cluster, it's not rare to find these kinds of partnerships. These alliances are a clear example of the need of a codeveloped offer since the very beginning of the projects. On one side these could be explained as the attempt of plant engineering studios to exploit these partnerships to increase their market presence and put the roots to become the leaders in the industry. On the other side, the highly specificity and integration needed by the Smart Building projects crave an early cooperation and creation of a codeveloped offer since the very beginning of the creation of the project, and the general contractors are the best designated players, present since the very beginning.

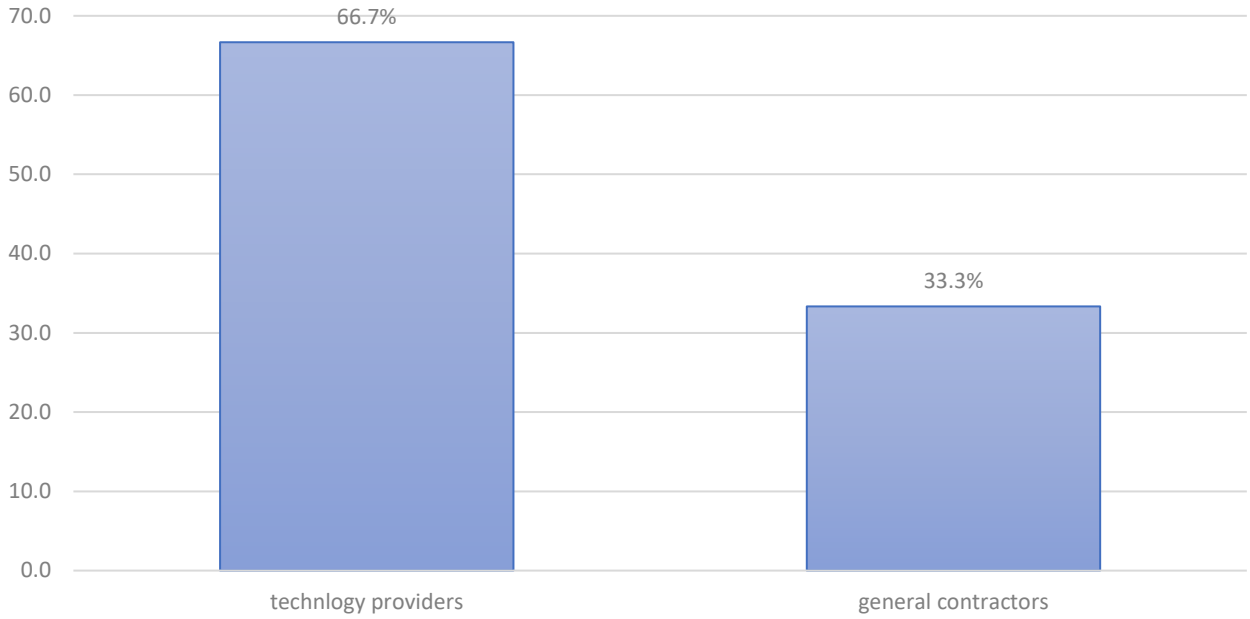

Figure 13: Plant engineering studios' alliances

As shown in the figure 13, the plant engineering studios' cluster consists in two types of partnerships. The first one, very strong, with technology providers. That has as purpose the integration of systems and technologies, to improve the offer and provide to customers the most seamless experience possible. This partnership found strong references also in the technology providers cluster. The second one is with general contractors, to underline the need of a deep integration since the very beginning, since the birth of the Smart Building project. Both the two alliances types' purposes are the co-creation of a common, shared offer that brings on board all the players, to deeply integrate the two worlds and have strong roots since the very beginning of the creation of the building.

5.1.5. Facility Managers Partnerships

The set is constituted by four interviewed companies that resort to four overall partnerships; clustered into three sub-categories.
Facility managers and:

- Technology providers.
  The leading number of alliances is, also in this pool, the one with technology providers with two, the 50% of the players in this group resort to these. Explainable with the need of facility managers to have a building management system, BMS, and more in general all the monitoring and maintenance systems in the building made ad hoc for their requirements. For these reasons the need of a technological partner in the ideation of the project and the creation of the systems is fundamental, that not only provides the technologies needed in that specific project but is the co-developer of the product/service and could also act as installer of the system.

- Plant engineering studios.
  The 25% of the players belonging to this cluster, one listed partnership, resort to this alliance. The reasons are similar to the previous sub-cluster; the need to have a system ad hoc that fits at best the facility manager's needs and the building itself. For this reason, the co-development of the plant is made through partnerships that are fundamental for both the development of the product and the installation of it inside the building.

- Universities and research centers.
  Only with one listed partnership, this is, nevertheless a very interesting type. The aim of this is to increase the knowledge in the new industry and at the same time access to a network of companies and practitioners in the field that can increase not only the knowledge of the sector but also boost networking and possible future partnerships as direct acting players and not only as spectators.

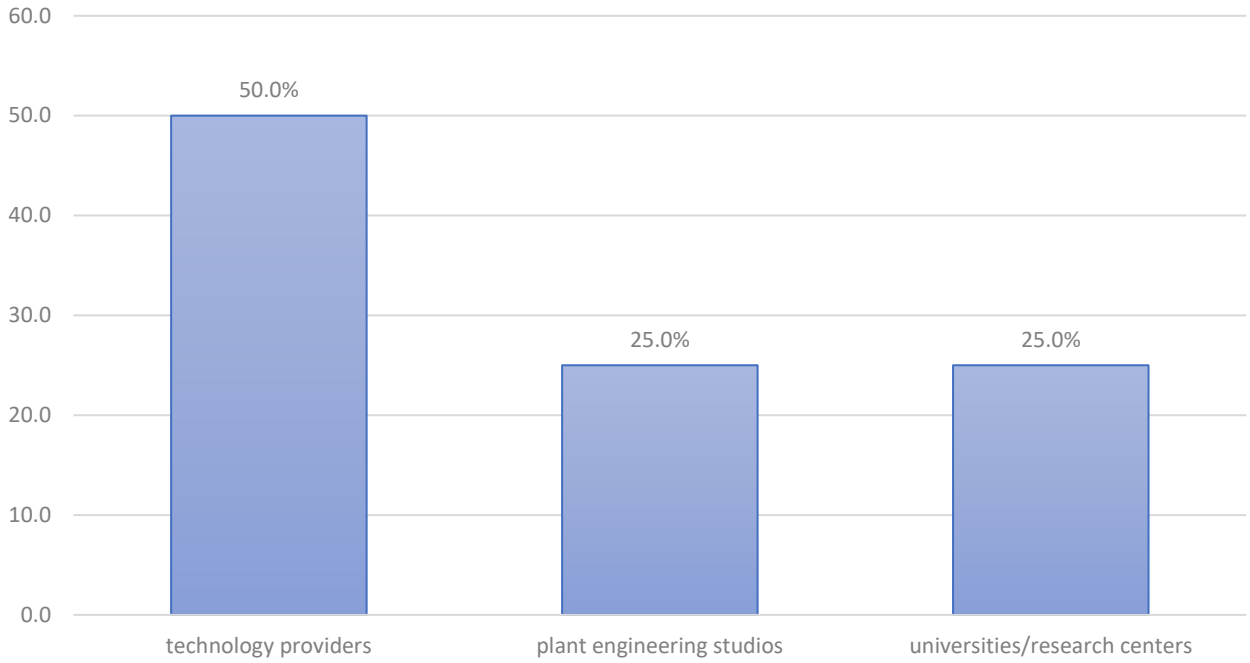

Figure 14: Facility Managers' alliances

The sector, as shown in the figure 14, for the whole majority is constituted by partnerships whose aim is to co-develop the needed products from the ideation of the project, through the choice and integration of technologies and systems, till the installation of those in the buildings. These partners, technology providers and plant engineering studios, are very useful because they also act as installers. A percentage is also dedicated to partnerships that have a completely different purpose. The alliance with universities and research centers is in fact aimed at increasing the understanding and the knowledge of the resorting company in the sector and in the industry, creating at the same time a network of companies and practitioners useful in the future.

5.1.6. Utilities Partnerships

This set of interviewed companies is pretty scarce, only two companies, but the choice to include this in the single cluster analysis and not only in the final general analysis held in paragraph 5.2, is because of the interesting results came out from the interviews with two big players in the industry. The two companies resort in three overall partnerships clustered in two categories.
Utilities and:

- Universities, research centers and innovative companies.
  Both players, the 100% of the set resort to this kind of partnerships. For mainly two reasons, access to new specific complementary technologies not developed internally and acquisition of these, to improve the current offered services or creating new ones, and co-development of new offers and services with small innovative very digitalized companies, such as start-ups. The deep connection with the research world can also help to increase the knowledge on the new innovations and the development of the industry.

- Software providers.
  Just one of the two companies resort to this partnership. The alliance shows the need of a customized software ad hoc that is able to monitor clearly and in real time consumptions and the electricity peaks of the network to reach the final goal of providing energy at demand and absorb it from buildings when not needed. Also, the need of a BIM system, building information modelling, clear and updated to do that push companies to recourse to partnerships because of the lacking competences.

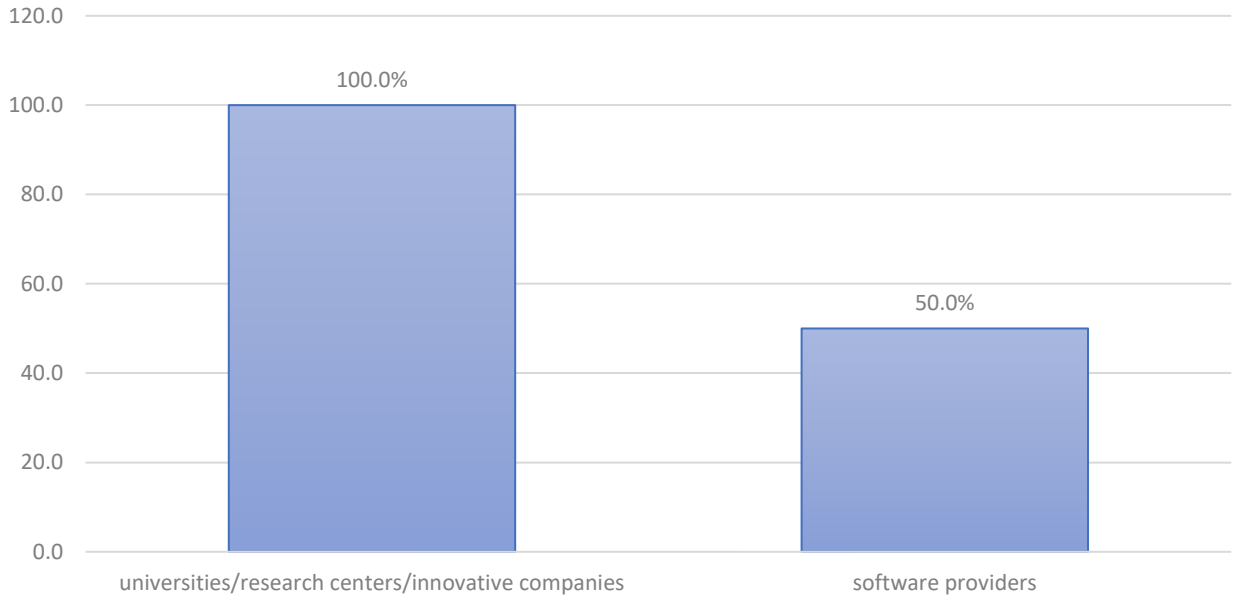

Figure 15: Utilities' alliances

This last cluster could be defined as the most atypical of all. Beside the more expected partnership with the software provider, the two companies have chosen not to resort to classical partnerships with, for example, technology providers like is present in the Aspern Seestadt case study, but to explorative partnerships. These alliances are mainly aimed at exploring new technologies and use the knowledge generated by the innovators to improve or create new offers, not acting as an integrated player in the market putting together core services with other complementary ones accessed through cooperation.

5.2. Comparative Analysis

In this second phase of the analysis, the data are considered all together, not constrained by the clusterization adopted before, this to better explain the appearance of trends and patterns in the Smart Building industry. The tendency of firms to have more than one partnership resulted into 80 overall alliances counted, respect to the 51 interviewees. In the following paragraph first are shown the overall alliances made, grouping them, providing a clear idea of the most resorted partnerships of the interviewed set, then the reasons that stand behind the creations of partnerships are explained.

In the description of the grouped data those partnerships registered only in a single, beforementioned, cluster weren't further described because these have been completely talked about in the previous cluster description. These are listed in both the figure 16 and in the following description but do not have a standalone paragraph. Only exception of these are the partnerships belonging to the "TELCO" and "General Contractors" clusters, that have not been mentioned before.

The analysis of the grouped data strengthens the findings of the clusters analysis. Grouping all the partnerships some strong patterns came out, easily identifiable in the figure 16.

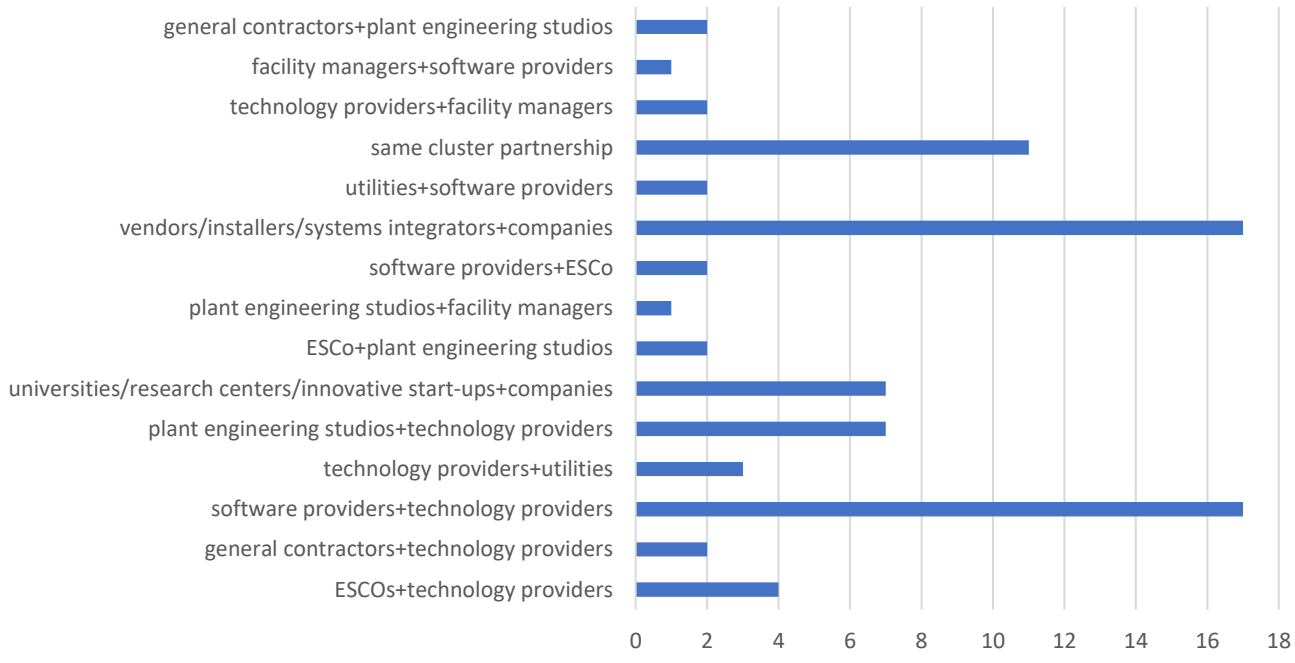

Figure 16: All the listed partnerships found in the dataset

The two leading categories with seventeen listed partnerships each are the partnerships between software and technology providers and the alliances of various firms with vendors, system integrators and installers.

The first one was already identified as a very recursive in both the technology and software providers' clusters, its leading position is a clear exemplification of how the technological, physical world and the IT based one need and must be in close contact in the Smart Building environment, and how the integration of these two world can lead to great projects, see Chorus Life and The Edge case studies. This two clusters are also characterized by huge, well-known multinationals companies that operates all around the world and that are more prone and confident in resorting to alliances to provide the best experience possible.

Considering the latter, it was preferred to group in the same category on one side, vendors, installers and systems integrators, and on the other all the players belonging to the clusters defined in chapter 4. The choice of grouping all the different firms under the label "companies" was made considering the reasons that bring firms to resort to these alliances; that are common to all the different firms, basically commercialization and installation of products. The decision of putting together the first three categories, vendors, installer and system integrators was, instead, made aiming to create clearer patterns, since the three firms are similar and sometimes their activities overlap. It's clear then how these partnerships' purpose is merely the commercialization and installation of products, that many companies entrust to partners.

The third position is occupied by the partnerships with the firms belonging to the same cluster, with eleven listed findings. So, for example, alliances between two different technology providers. In the Open Innovation paradigm, it's not strange to find these kind of alliances, see paragraph 2.5.3, and this industry confirms this tendency. The numerous technologies and services needed inside a Smart Building can, in fact, bring competitors to cooperate, focusing on different products or services, or different parts of the value chain. This is true for both big incumbents and small firms. Since the very wide portfolio of big firms enables them to provide the complementary technologies needed in the projects and be part of it even in presence of a same industry player, and the high specificity of products or services typical of small firms gives them very specific capabilities on some products/services that big incumbents can lack. A clear example of same cluster joint development of a building is presented in all three cases studies: in Chorus Life and The Edge case study, where two technology providers codeveloped the buildings, and in the Aspern Seestadt one, where two utilities are involved.

With seven listed cooperations there are two different categories: alliances between technology providers and plant engineering studios and alliances between firms and universities, research centers, innovative startups.

Starting with the first one, these were found in both the technology providers' and plant engineering studios' clusters showing how recursive these alliances are. The need of a strong integration between technologies and the various systems needed in the building (wiring, heating, monitoring, automation systems) is the roots of these collaborations.

Regarding the second category, as in the previous example different firms were labelled just as "companies" because the reasons that push them to create these alliances are quite the same for all; either increasing the knowledge of the market, the industry and the operating companies or technology access and acquisition. Universities, research centers and innovative startups were gathered in the same category for patterns identifications like before, since also here their activities are very similar and sometimes overlapping. The Edge case study is an exemplification of this collaborations, the collaboration of a small university-based startup with big incumbents.

The overall partnerships between ESCos and technology providers count four cases, spotted in both clusters, represent the need of both companies to codevelop their offers integrating ESCos' energy services with the technology providers' energy related technologies (HVAC systems, lighting), to create the most fluid and easy to use environment.

The partnerships between general contractors and technology providers present two listed cooperation. Showing the need of a codeveloped offer since the very beginning of the projects. The highly specificity and integration needed by Smart Buildings projects crave an early cooperation and creation of a codeveloped offer since the very beginning of the creation of the project; in this way a deep integration of technologies is assured, and the buildings gain from that.

The last set described represent the partnerships between utilities and software providers. Even if it counts only two cases, this are split in the two partners' clusters encouraging the idea that it's not a single isolated case but a possible behavioral pattern of these two firms' typologies. This pattern shows the need of a customized software ad hoc that is able to monitor clearly and in real time consumptions and the electricity peaks of the network to reach the final goal of providing energy at demand and absorb it from buildings when not needed. Also, the need of a BIM system, building information modelling, clear and updated to do that push companies to recourse to partnerships because of the lacking competences.

This second part of the overall analysis wants to explore the reasons that stand behind the creations of partnerships in the Smart Building industry and see if some motivations are more recurrent than others. The main, big purpose that stands behind the use of collaborations, partnerships and so on is the willingness to gain missing knowledge, and with it, missing competences. Since the single player's ones are not enough to perform successfully in the market, and it's excluded the development of these from scratches, at least from the very beginning of the birth of the industry. There are different types of knowledge that firms need, depending on their cluster, traditional industry, strategies, aims in the market, competences, culture, organizational boundaries and so on, and with it, different competences. Hereafter, as shown in the figure 17, all the reasons, and then knowledges, that pushed companies to collaborate are listed and described.

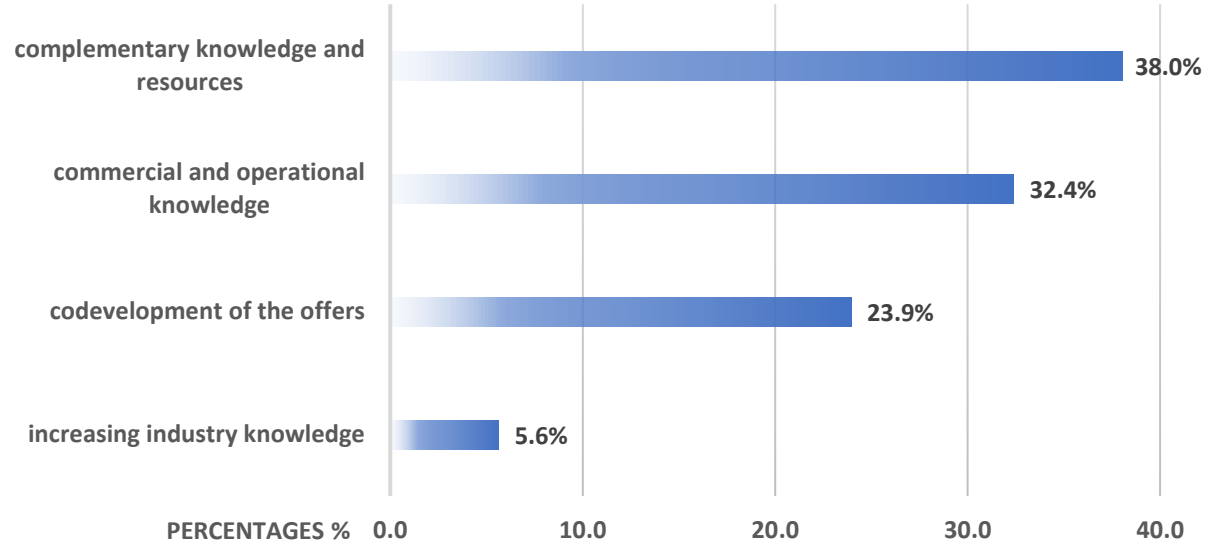

Figure 17: Knowledge/Competences looked for

- Complementary knowledge and resources.

  It's the most researched knowledge of the set. The convergence of the industry makes fundamental the access to complementary technologies since the competences belonging to just one traditional sector aren't enough anymore. Resorting to external complementary knowledge and competences is the easier, faster way to access the missing competences that allow firms to enter and do business in the Smart Building industry. Moreover, the huge investments needed to develop from scratches new competences with roots outside the firm's industry push the companies to look outside their perimeters and search for alliances

and partnerships. Knowledge access could take place in many different ways and with different partnerships types: equity sharing, joint venturing, licensing, R&D shared development and so on. This depends on the level of integration needed by the acquiring company and the level of knowledge of the accessing competences. This purpose is very close to the co-development of the offer one, but it can imply less interaction and involvement level of the two companies; in fact, differently from the latter the two companies can interact as standalone entities that resort to licensing to give access to one to the missing technologies and knowledges.

The missing competences can be a very wide concept, and these go from knowledge till technologies and assets. The choice of relying to the market for knowledge, technologies or the market for assets depends only on the desired level of property rights on the acquired products/services. This type of alliances is spread in all the clusters and can involve two firms belonging to closer industries or two belonging to distant ones indiscriminately, the difference will be in what companies will look for and how they will interact.

Firms access and obtain technologies instead of competences because often these already possess the competences needed to integrate the new technologies in their own ecosystem. The access and acquisition of technologies is, then, facilitated if the two companies belong to industries not so distant one from the other, the closeness should in fact favor a higher absorptive capacity of the acquiring firm facilitating the digestion of the acquired technologies.

- Commercial and operational knowledge.

  The need to access to the commercial and operational knowledge is particularly high in the Smart Building industry. This knowledge is about the general understanding of the market, the customers presence in it and how to better reach them and interact with them, being able to provide all these accessories' services that go beyond the selling of the products/services. Firms, especially big ones with very wide products and services' portfolios, create alliances with vendors to gain access to more specialized commercial knowledge and competences and to commercialize their products reaching and get in contact with customers otherwise unreachable or of difficult reaching. This alliance is used mostly to reach the mass market for small plants and buildings, not in big, complicated new projects where the presence of the selling company is crucial but where installers and DIY is

facilitated by the smallness of the projects. The resorting company commercializes finished products easily integrable in small, simple and ready to use ecosystems, that could be then integrated with complementary services and products by third parties. The alliance for the commercialization permits to the relying firm to increase its market presence and revenues enlarging its operating base, saving at the same time and resources that would be dedicated to a retails' sales force creation, and on the other side to focus its effort on others, more important, projects.

The operational knowledge is somehow similar to the commercial one, and sometimes these are bond. Sometimes, in fact, the companies that are involved in the commercialization of products are also involved in operational activities, such as their installation. Their shared characteristic is that they both have a practical purpose; not aimed at investing resources into creations of new, improved offers for customers, but to more effectively and efficiently address the market. Firms create partnerships to install their products, in this way they can avoid investing resources to create a property installing force but can resort to professionals that can better reach the whole market and are specialized in systems installations. This type of installation is fit to reach the mass market, characterized by small, simple projects, but also for big, high investment requiring projects. The difference between the two categories is that the level of involvement of the resorting firms will be higher in the latter. In fact, for huge projects, the companies resort to close-contact alliances, that enables them to also create customized ecosystem, that are not needed in smaller projects.

- Codevelopment of the offers.

  This purpose, that firms look for in the partnerships creation, is close to the access to complementary knowledge and competences; that the convergence of the industry makes fundamental to access. Resorting to external knowledge and competences is the easier, faster way to access the missing competences that allow the firms to enter and perform in the Smart Building industry. Moreover, the huge investments needed to develop from scratches new competences with roots outside the firm's industry push the companies to look outside their perimeters and search for alliances and partnerships. The co-development of the offer is a direct consequence of this; the high specificity of knowledge and competences and the need of a deep, strong integration between them crave the joint development of services and products, to create a more fluid and seamless experience for

the final users. This goes more in dept of the mere access to complementary knowledge and competences, since the nature is more of co-creation and joint provision of services. While the first can be more generic and occasional, bond to single projects or services, this is more long-term oriented and requires a deeper involvement and investments of companies.

Is typical of firms belonging to industries very distant one from the other, that are trying to gain a leading position in the market creating new, integrated, improved, seamless ecosystems, for example technology and software providers; these two players, no matter how big they are, don't own enough capabilities to act as an alone, all integrated player in the market but are forced to rely on partners. And codeveloping a new offer is the best way to create a "standard-setting" product/service, customize on the customers' needs and completely integrated.

All the cases studies hereafter taken into consideration show very well how these alliances are needed and how the projects will benefit from these.

- Increasing industry knowledge.

  This is, despite the low percentage, only 5.6%, a very interesting purpose. Is mostly made by companies with universities and research centers or consultants. These in fact are a huge source of fresh information about the market, its main players, the technologies involved, the main trends, its customers and so on. Moreover, these actors can also boost a firm's networks of knowledge, putting it in contacts with practitioners, external consultants, other firms operating inside the university, small innovative startups. A doubtful, or unsure of its networks firm relies on these alliances to increase its industry knowledge and have a clearer understanding of the overall picture and if it has the competences and capabilities needed to enter and perform successfully in the market. Or it uses these relationships to increase its knowledge on a specific part of the industry, such as the technological ground, the new innovation trends and their development.

5.3. Cases Study

The cases study taken into consideration are three, Chorus Life, The Edge and Aspern Seestadt. Chosen to strengthen our research topic and to give a more structured understanding of the partnership undertook in the Smart Building industry. In the following chapter the three cases study are described in detail to give a real example of what Smart Buildings and Smart Cities are. Moreover, the partnerships, that some of the actors involved in the creation of the buildings undertook to perform at best and provide services and products to match the new standards created by the industry, are analyzed and described. To provide a real example, and to support the empirical result coming from the data analysis.

5.3.1. Chorus Life

"Chorus Life is a city model where the three generations can live, socialize and grow together while sharing the same space. It is a community understood as a combination of services but above all as a social whole, in which all barriers are eliminated in order to promote the integration among individuals, in full respect of the environment. Thanks to a pioneering real estate system that combines the art of building with industry, architecture with state-of-the-art digital technologies, Chorus Life is a center of socioeconomic aggregation for the improvement of wellbeing and quality of life by offering a major opportunity for development and economic growth". Cav. Lav. Domenico Bosatelli.

Figure 18: Chorus Life project rendering

Chorus Life is a requalification project of an urban-industrial area of roughly 70.000 sqm in Bergamo, starting from the idea of a city where social benefits, economical profits, sustainable architecture and smart technologies are deeply integrated. Where the urban model puts the individual and its needs at the center of the whole project. In the realization of the project three objectives were considered fundamental. (i) The human element valorization, individuals are the bullseye of the urban format constituted by Chorus Life. Everything is thought to improve their lifestyle, re-gaining their social dimension, enabling them to save time for themselves and improving their mind and body. (ii) The urban regeneration, old abandoned areas must be exploited and regenerated, instead of building from scratches. Reshaping and completely transforming them into new trending neighbors, where people can find a place to live, to explore and a space that provides a wide range of services. (iii) The area redevelopment. Cities' geography positively evolves, taking care of abandoned and not livable areas, thanks to a careful and aware architecture these areas are re-given to the citizens building new high energy efficiency urban parks dived in nature.

Chorus Life will include housing facilities, a hotel, open spaces, an event arena for 6.500 people (for concerts, conferences, …), ristopubs, gyms and wellness facilities, a 25.000 sqm park with squares and facilities and parking lots. All of these will be powered by digital technologies, making them smart and able to provide enhanced services to people. The digital, integrated nature of those have brought companies to offer these products/services differently. For example, the flats won't charge just the rent fee but an integrated and scalable offer of housing services, energy, maintenance and security. The new "rent", of these Smart Homes, will includes all or part of the integrated housing services, as internet connection, cleaning, maintenance and external services available in Chorus Life (access to leisure terrace, gym and wellness areas and others).
Moreover, to power Chorus Life a Smart Grid system has been designed, which will distribute energy according to real needs, avoiding waste and reducing environmental impact. Sensors will collect information on production and energy consumption in real time, and all the data, in addition to monitoring consumption, are used for predictive purposes (maintenance, security,…), to adapt with flexibility the energy production and consumption of the Smart Buildings and the Smart City itself.

Figure 19: Chorus Life, description

The project was awarded of the "WT SmartCity Award, international urban & architectural competition" in 2017, by Well Tech Studio and Metropolitan City of Milan for visionary powers and technological innovation. The "WT SmartCity Award, international urban & architectural" competition is to reward the most visionary and sustainable ideas and projects to transform in a positive way the landscape.

Analysis Findings

The three ground characteristics of Chorus Life are:

- A laboratory of technologies applied to plant engineering.

  A Smart Grid system support Chorus Life, suppling energy at need, avoiding any possible waste and minimize the ecological footprint of buildings (Smart Buildings) and the city (Smart City). The GSM platform, hereafter described, will shape the technological infrastructures and provide the mobile communication, fostering both physical and virtual contacts between individuals and communities.
- An opportunity for development and economic growth.

  The project relaunches the building sector creating new jobs, but it also poses a challenge to innovation, facilitating development opportunities for the construction industry, integrated with service such as home automation, landscape designing and architecture.
- A new vision of the social fabric.

  Trough the smart arrangement of spaces and technology at the service of human life, Chorus Life allows different generations to meet and confront each other in an authentic way. The absence of architectural barriers and a high relational density, promote the conditions for an improved quality of life, based on the wellbeing of social integrated individuals.

The new Smart City will be constituted by the GSM (Global System Model), the new technological platform for urban systems that uses ELMET (electro mechatronics technologies) for a complete managerial interaction of digital infrastructure and plant engineering. Though it, the digital infrastructure and the plant engineering can be integrated, enabling the physical and virtual exchange benefitting the individual and the community.

The GSM model will coordinate the mobile communication between people and technologies that will have numerous IoT applications, favoring the exchange between physical and virtual, simplifying and making more efficient the life of the individual and the community. Creating a single but extremely flexible application for the user to access to all the service integrated in one portal to monitor and manage a whole area, highly customizable on its needs. The network interconnection of buildings, beside enabling a remote control of those, produces a huge quantity of data that are extremely useful to develop tailored applications and digital services.

In particular services that will increase the comfort, safety, security, productivity and sustainability levels of each building and user.

Figure 20: GSM description

As explained in the paragraph 3.2.1., the Smart Building industry is a convergent industry, therefore companies need to interact one with the other and create partnerships to being able to provide services satisfying industry's standards, no company can act completely alone, but a deep, continuous co-development of products/services is fundamental. Not only because of the literally understanding of the industry convergence itself, "*the converging of two or several hitherto separate industries*" (Weaver, 2007), so the real lack of competencies of one industry to provide cross-industries services and products, clearly represented by Smart Building as discussed before. But, also for the nature of the Smart Cities and Smart Buildings projects, requiring high monetary investments, involving many different actors, with a very high level of technology involved, the continuous and fundamental interaction between digital and physical world and with a big impact on the society push companies to resort to alliances since the very beginning of the projects. Therefore, companies choose to resort to partnerships and collaborations to limit the risks, but also

to gain faster that knowledge that they lack to offer products or services that match the new requirements of the converged industry, avoiding huge initial investments in technological research.

The GSM is the result of the collaboration between three big companies, Gewiss, Siemens and Microsoft.

- **Gewiss.** Is an Italian technology provider, based near Bergamo, that offers solutions and products for the buildings automation, smart lightning, smart energy control, smart products for electric system protection and efficiency.
- **Siemens.** Is a huge German multinational technology provider with a very wide portfolio of products and services. It operates in the system and software fields offering different types of products, systems and solutions for the realization of buildings automation systems, electrification and digitalization systems, HVAC, micro & smart grid and in general all the energy transmission solutions all based on IoT technology and Cloud solutions.
- **Microsoft.** Is a huge American multinational software provider that develops, and sells mainly computer software, cloud platforms and analytics services, such as Azure, an ever-expanding platform of cloud computing services. Also active in the area of consumer electronics, personal computers and related services.

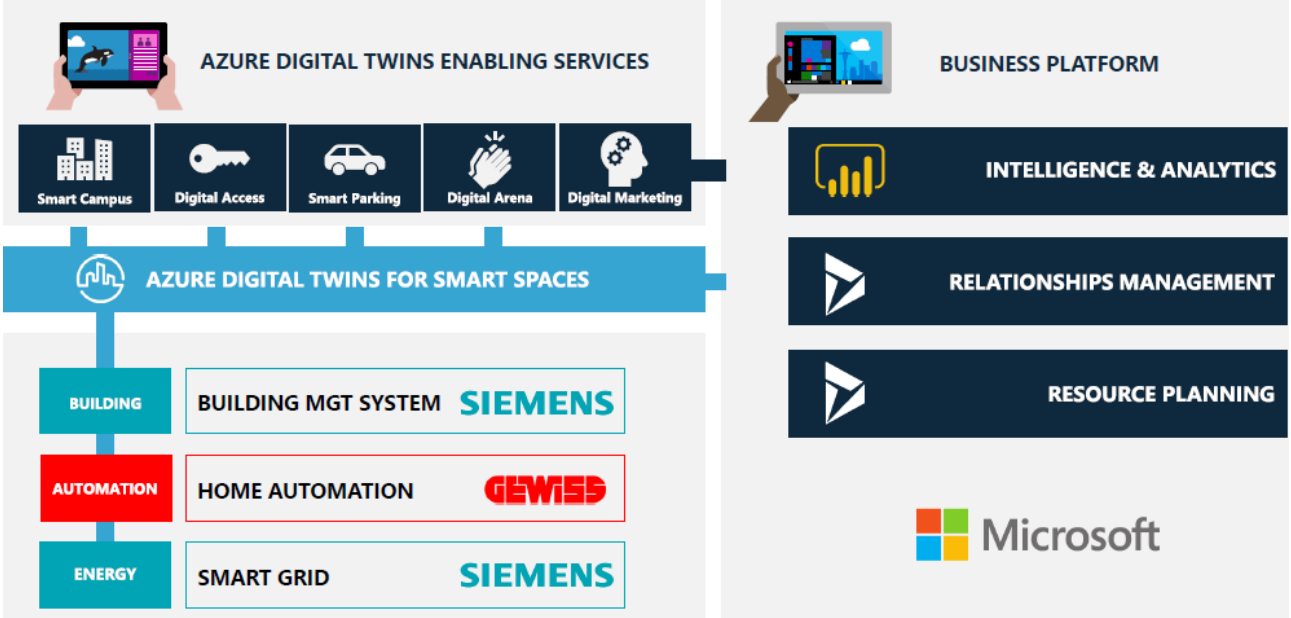

Figure 21: GSM, partnership's configuration

This is a clear example of how partnerships are the root of success in the Smart Building world, since these three big incumbents resorted to an alliance to provide this new digital integrated platform which will integrate the building automation products, the smart grid and the building management system into a business platform that will digests all the data using analytics techniques and offers to users the possibility to view and manage solutions depending on their needs. For example, visitors or residents will receive trough dashboards and mobile apps basic data about their own house or public facilities, while building managers will receive more precise data, about all the buildings, useful to monitor the general wellness of people and the buildings and usable for additional purposes (business analytics, energy forecasting and optimization, light management, smart cleaning, predictive maintenance,…).

Gewiss will provision all the building automation products, such as the integrated smart lighting and control systems and products for the electrical plant efficiency. Siemens will instead provide the smart grid for the energy generation, the building management system and others building automation products. All this smart objects and sensors that will gather tons of data per day will be integrated by Microsoft Chorus Life Cloud. This through Azure Digital Twins, an exact digital replica of the physical buildings, processes, people, systems and devices, enables customers and partners to create a comprehensive digital model of the physical environment, including people, places, things and the relationships that bind them.

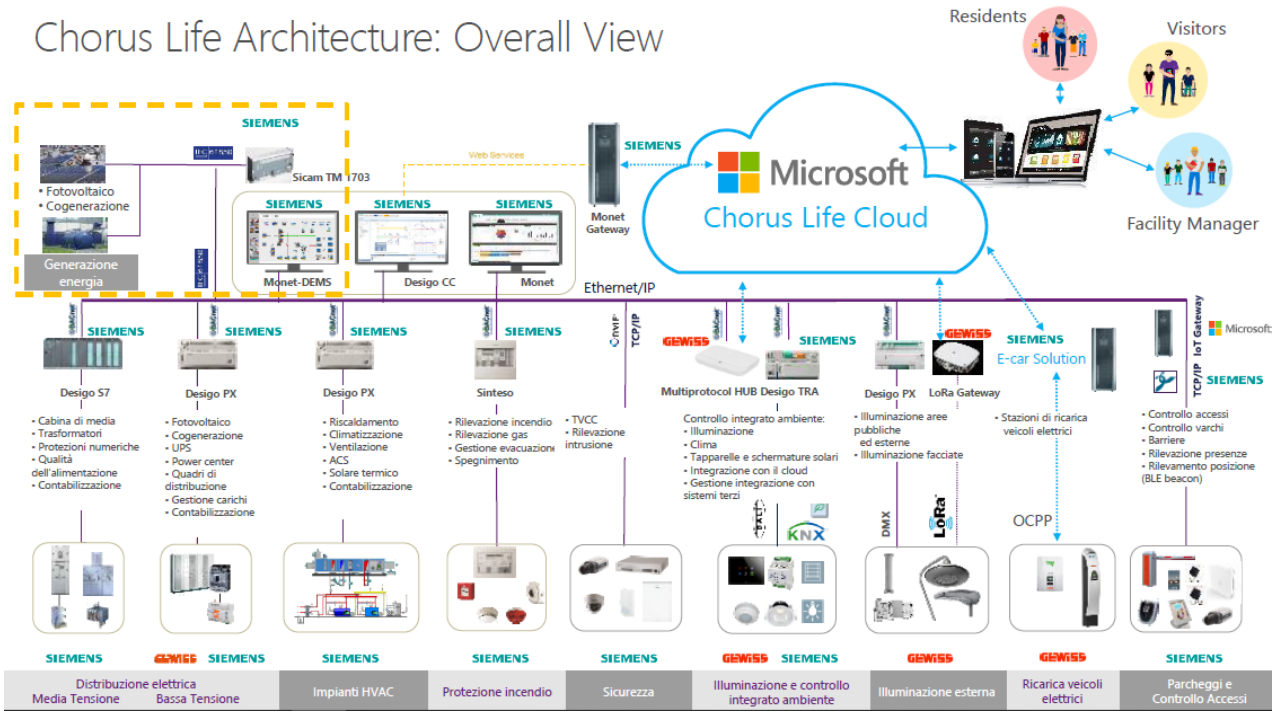

Figure 22: Chorus Life Architecture Overall view

Is crystal clear how the GSM couldn't have been developed by a single company alone, even if two of the three partners are big multinationals with very high innovation capabilities and resources. Not only for the enormous complexity of the project and its cross-industry nature but also for the gigantic investment, monetary and in time terms, needed to develop the lacking capabilities in house. This with many others Smart Building services crave alliances, partnerships and in general cooperation between different actors, even competitors (Siemens and Gewiss).

5.3.2. The Edge

"It knows where you live. It knows what car you drive. It knows who you're meeting with today and how much sugar you take in your coffee. (At least it will, after the next software update.) This is the Edge, and it's quite possibly the smartest office space ever constructed." (Randall 2015).

Figure 23: The Edge

The Edge is a 40.000 sqm office building property of the consulting company Deloitte, located in Amsterdam, and it is the greenest office building in the world[1]. It created a radically new working environment that is enabled by sustainable smart technologies.

The building interacts with the workers as soon as they arrive, by feet or car, through an app, developed by Mapiq with Deloitte participation, recognizing and assigning them a workspace for the day, based on their own schedule and daily assignments. There are sitting desks, standing desks, work booth, meeting rooms, balcony seats, concentration rooms or even in the atrium is possible to stay and work. Following the "hot desking" concept to reduce the number of desks in the company but maintaining or increasing the number of employees. It's the new way of working, using information technologies to shape both the way of working and the working spaces. Hot desking encourages relationships, interactions and efficient use of space, because desks are only used when needed, the lack of an office is solved with lockers to put personal items for the day. The app automatically sets the light and temperature levels that you prefer in the room and enables the single person to change the room settings from it, to personalize the room at your likeness. The app is conceived to let lights flick in conferences rooms 15 minutes before the end of the booking of the room itself, to indicate wrapping up in time for leaving it or for the next meeting.

[1] According to the rating agency BREEM, that gave it a sustainability rating of 98.4%

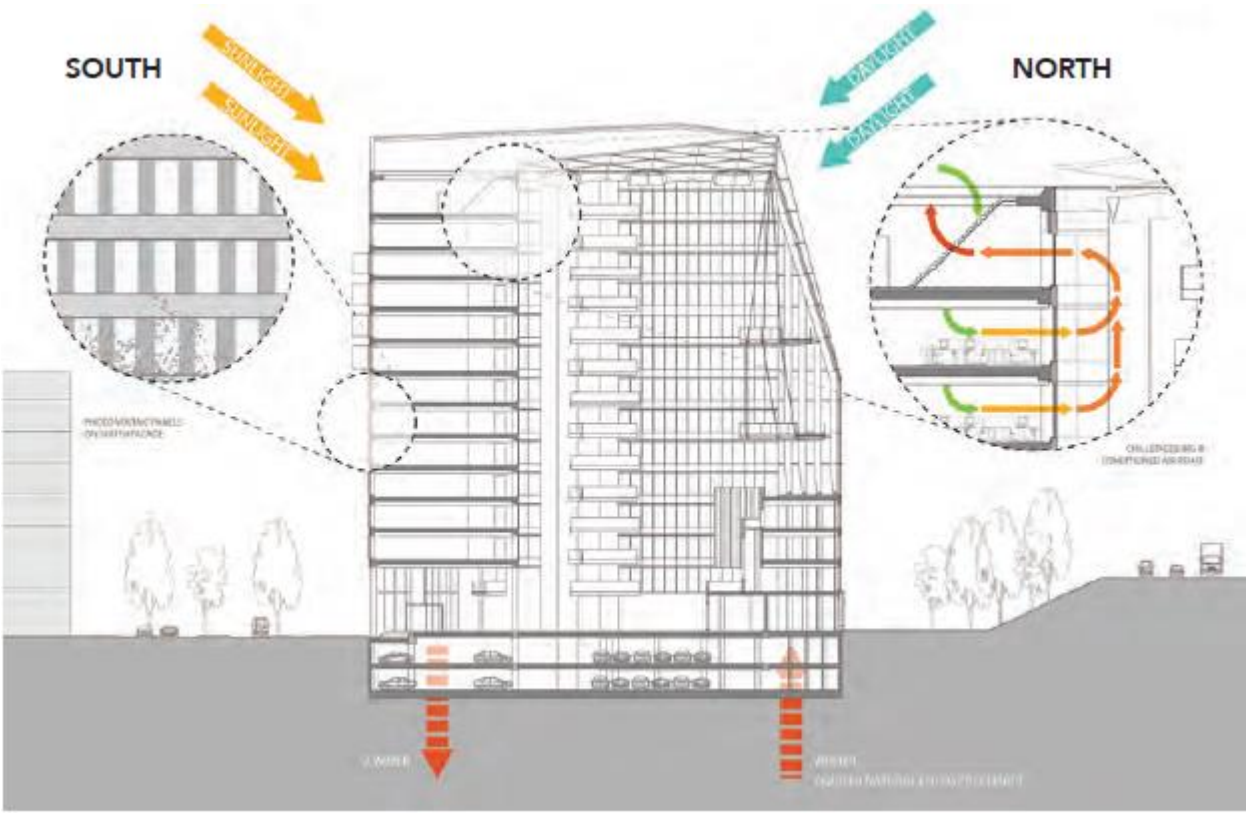

Figure 24: The Edge's air recycle system

The building's orientation is based on the path of the sun, the atrium is the gravitational center of the Edge, panels at each floor let air circulate from offices to the open space and exhaled through the roof, emitting fresh cool air from the floor creating a loop of natural ventilation. The big windows that cover all the walls and part of the roof are a source of natural light in every weather condition and season. *"A quarter of this building is not allocated desk space, it's a place to meet. We're starting to notice that office space is not so much about the workspace itself; it's really about making a working community, and for people to have a place that they want to come to, where ideas are nurtured and the future is determined."* (Ron Bakker, architect of the Edge)

The Philips' LED super-efficient panels require such a low level of electricity that can be powered trough the low voltage internet cables, making each single light of the building an internet connected data hub. Moreover, the use of sensors (motion, temperature, light, humidity and infrared) for each single panel creates a "digital ceiling" that provides control and monitoring of each single centimeter of the building, the Edge is packed with 28.000 sensors.

The enormous amount of data that Deloitte collects every day on the Edge, its employees and the various interactions are secured and showed into dashboard that describes all the different aspects of the building, from the energy use to the need to refill the coffee machine. This system is able to optimize spaces, consumptions and operations, closing down sections of the building if few people are expected at work, cutting down the costs of heating, lighting and cleaning. In the building is used the Schneider Electrics' EcoStruxure Building Operation a BMS user friendly to optimize the building performances, whose 50 servers gather and analyze the data captured by the aforementioned sensors, able to integrate property technologies with third part ones.

Figure 25: EcoStruxure Architecture

The Edge is a net-zero energy building (NZEB), it uses 70% less electricity than comparable office buildings; the whole building is powered by the sun, the southern wall alternates windows with solar panels, reducing the sun exposition and generating energy at the same time. The roof is completely covered by solar panels that are able to entirely cover the energy needs of the building and its inhabitants, including the electric cars recharging system, the Edge can, in fact, produce more energy than it consumes. To be even more efficient the building uses an aquifer thermal energy storage system as heating and cooling system, that is based on the pumping of warm water in an apposite aquifer deep in the ground during summer, 130 meters beneath the building, where it stays, completely insulated, until winter, when the building pumps suck it back out to use it for heating. For this reason, the Edge is wired not only by the classic data wires but it has behind each ceiling tile wires that hold water for radiant heating and cooling purposes. Robots are used for cleaning and security purposes, autonomously or remotely coordinated. The smart cleaning services

activities are tracked during the day through heatmaps, facilitating the cleaning workers, robotic or not, that are addressed to the most used areas of the building in that day.
Even the rainwater is collected to flush the toilets and to water the external gardens. Birds, bats, bees and bugs are warmly welcomed in the northern façade and in the gardens, the Edge is in fact provided with birdhouses and hives to incentivize their presence and sustain the local pollinators and vegetation.

The realization of this magnificent building was made possible by many partnerships and close collaborations between different actors.
In particular, Schneider Electric, an important technology provider that handed out a broad range of integrated building management solutions, electrical distribution systems and IT infrastructures, create different alliances, with the property developer (OVG real estate), the lead occupant (Deloitte), the system integrator (HC Groep), other technological providers (Philips) and software providers (Mapiq). These partnerships represent a new way of acting of companies, as presented in the previous chapters. Schneider Electric embrace this new way of interacting and doing business in its latest creation, the EcoXpert Partner Program; a program that unites the world's leading solutions providers, who exhibit best-in-class system integration competencies in facility optimization, reliable infrastructures, and energy management, with its customers around the globe. Stronger together, these partnerships cultivate collaboration, connect expertise, and deliver best-in-class services and solutions.
For example a deep partnership with HC Groep, a leading Dutch system integrator was established to enhance the most the capabilities of both companies and ensure the perfect functioning of systems and products in the shortest time possible, *"During the bidding process we worked closely with Schneider Electric to ensure that the newest building automation technology was available and could be integrated in all the emerging new technology in The Edge"* (Jacob Jansen, General Manager of HC Groep).

The most remarkable partnership that enabled to create The Edge and made it such an extraordinary building is the one between: Schneider Electric, Philips and Mapiq.

- **Schneider Electric.** Huge France multinational technology provider with a business portfolio very wide. It offers different types of products, systems and solutions for the realization of buildings automation systems, electrification and digitalization systems, HVAC, micro & smart grid, software for the energy management based on IoT technologies.
- **Philips.** A Dutch multinational technology provider that is focused mainly of the healthcare and smart lighting products. Providing products and services aiming to improve the general wellness of the people improving their life.
- **Mapiq.** A small Dutch software provider, startup born in the Delft University, that provides a cloud-based office management platform

Each one of them played a vital role in delivering these services that make The Edge the smartest building in the world. They start collaborating in the very early phases of the project, to better understand each other, their products/services, their way of working and the customer needs. Also, the early collaboration is an obligated step if the firms' aim is to integrate their respective technologies with the one of the others in the building; ultimate resulting in a sophisticated ecosystem that blended functional architectural solutions on a digital backbone. In the very beginning of the project Schneider, Philips and Mapiq were all bought together to identify overlapping areas where each could inform more integrated delivery of their services while getting users onto the same platform, avoiding to shift between various programs.

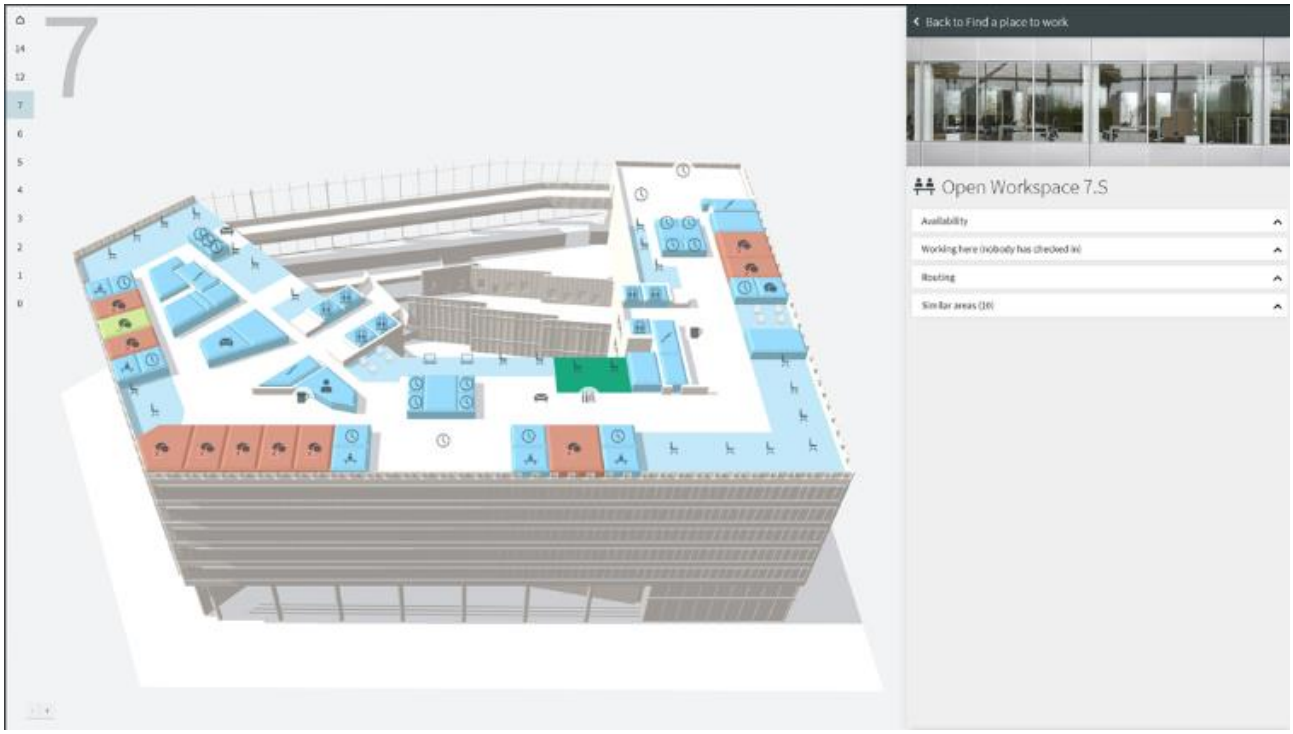

Figure 26: Mapiq's control dashboard

Philips was in charge of providing the LED lighting system powered by ethernet cables, this product was developed from scratches just for the building itself. Schneider, as said before provided the BMS, electrical distribution systems and IT infrastructures. Mapiq, a small Delft based company that was specializing in IT-driven workplace occupancy services, was bought on board to create the software, the app, and the platform that linked the Philips' smart light panels and Schneider's infrastructures in a single app. All the collected data functions as an input source for the Mapiq platform including its interactive 3D map, reservation system, lighting and heating management of each single user, where they can interact with The Edge and exploit its services.

5.3.3. Aspern Seestadt

"Seestadt is a new district of Vienna in which innovative concepts in the fields of housing, social provision, energy and mobility are being tested and put into action. In other words, Seestadt is an urban lab for the Smart City Vienna strategy." (Gerhard Schuster, CEO Wien 3420 Aspern development AG).

Figure 27: Aspern Seestadt rendering

The project was awarded as the “world’s best Smart Project” in 2016 by the “Smart City Expo World Congress” in Barcelona.

Aspern Seestadt is an enormous, 2.4 sqkm, long term project started in 2013 and planned to end in 2028, of requalification of Vienna’s 22nd district Aspern.
People often describe it as a “city within a city”, since the new district will house 20.000 inhabitants, providing residential buildings, offices, shops, commercial buildings, science and research campuses, schools and cultural facilities and parks. A Smart City within Vienna, just 25-minutes ride from the city center.

The new district will present three main types of Smart Buildings; a residential one, a student home and a school campus. These all will be equipped with solar photovoltaic and thermal panels, heat pump, electrical storage facilities and IT built in technologies. They will be “passive energy buildings”, buildings that are made by smart materials that collect, store, reflect and distribute the solar energy to reduce their energy consumption. Moreover, they not only use energy, but also produce and store it.

Figure 28: Aspern Seestadt Smart Buildings' activities

Through ICT (information and communication technology) systems the optimum, completely automated, management of energy distribution, consumption storage and transmission is handled; letting the buildings to participate to the energy market if the produced energy is more than the required, connecting the building with a smart grid. The smart meters and huge number of sensors in each room of the building will be the basic infrastructure of the building’s smart grid, the bidirectional connection with producers, storage facilities and real time consumptions monitoring will permit inhabitants to trade the unused energy. The Smart ICT collects and uses all the data obtained from the buildings and the network (temperature, air quality, electricity consumption, voltage, etc.) and external data, i.e. weather, and analyzes the interdependencies between the

networks and the Smart Buildings. Though Big Data analysis the new BMS provides the optimized energy consumption and distribution, reducing the energy production and avoiding bottlenecks completely autonomously.
Users will be able to directly control their house through an app connected to all the IoT devices inside their building. Creating scenarios and frameworks to personalize the house around their own routines and preferences, keeping tracks of their consumptions and of their home remotely, interacting with appliances to start or switch them off to save energy.

Aspern Seestadt is way more than just a Smart City. The project was born through a joint venture between five big players belonging to different industries; the new joint venture, managed by "Aspern Smart City Research GmbH & Co. KG, (ASCR)", was created in 2013 among: Wiener Netze GmbH, Wien Energie GmbH, Siemens AG Austria, Vienna Business Agency and Wien 3420 Holding GmbH. A co-operation model of this magnitude has so far been unique. More than 100 persons from different scientific disciplines are directly involved in this research project.
This companies didn't have as goal just the requalification of Aspern and the creation of a Smart City, but it has been conceived as a research project, that exploits the new created Smart City as a research center to innovate and improve the Smart Buildings and Cities concept and the smart technologies offered with them. The collaborative partnership main's goals are to exploit the potential of Smart Buildings of making energy flexibility available outside their walls, so energy trading, and to concentrate research on innovation of urban energy systems with the core topics of energy efficiency and CO2 reduction, including renewable energy generation sources and storage technologies (ASCR 2015), while using Seestadt Aspern as real-life laboratory, since it offers an unique opportunity to conduct research with real data of the built-up energy infrastructure of buildings, network and users. Moreover, as Seestadt Aspern provides a very diverse mix of residential, office, educational and leisure use buildings, it is a good testing ground for Smart Building research activities.

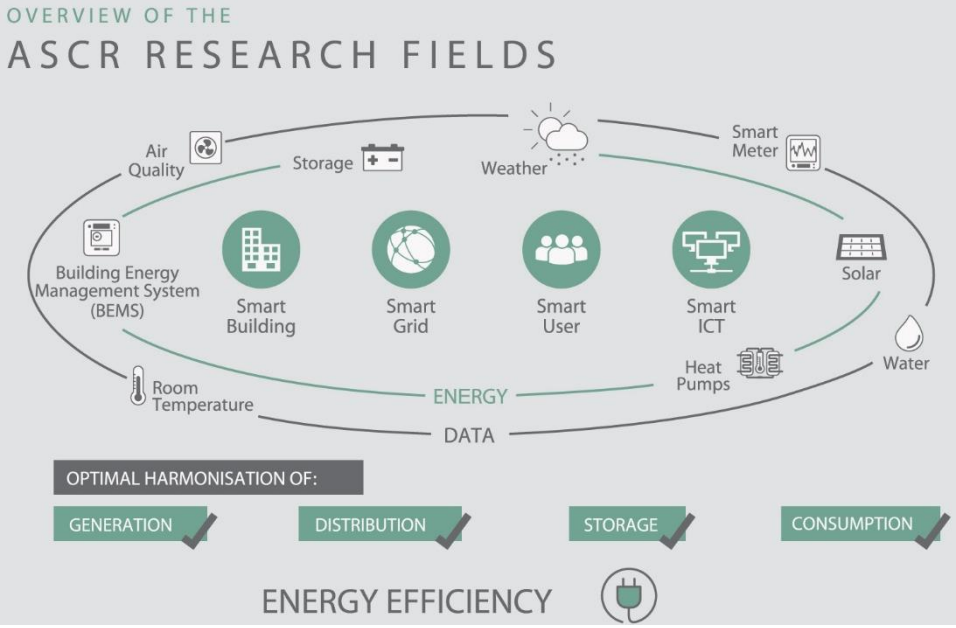

Figure 29: Aspern Seestadt research fields

The technical solutions for the future of energy are being developed in the real-life environment of a newly established urban development area with real end consumers. The project is focused around building automation and the use of energy flexibility of the buildings on the energy market, all with the involvement of smart users. Furthermore, optimal methods for the assessment of the Smart Grid condition and grid planning are developed. All solutions are based on a comprehensive ICT, for which the appropriate big data models are developed and tested.

In the future the analysis from the empirical extrapolated data will be usable to entire cities, thereby contributing to the development of a more efficient energy system with more careful use of resources.

Aspern Seestadt can be seen as the pilot project of the Smart City Vienna strategy, where the ecosystem is tested in this small reality to fix the problems and improve the services, using it to demonstrate its feasibility and its benefits. This will, eventually, brings all the building to become Smart Buildings and the whole city to become a Smart City.

Figure 301: Aspern Seestadt ownership structure

Seestadt Aspern is a great example of how companies resort to partnerships, joint venture in this occasion, in the Smart Building industry. In particular the five companies mentioned above in the figure 30, not only resorted in an alliance to create and power Vienna's new 22nd smart district, but also exploited this to continue their partnership in time to provide to Viennese the best Smart Ecosystem and use Aspern as a real-life laboratory to test new smart solutions and improve their knowledge and skills in the field.

Siemens provided the energy management system and implemented the advantaged building automation technologies. In particular it installed advanced transformers and Smart Grid technologies, cabling all the buildings and the district, moreover, these were provided by Siemens BMS, that enabled the predictive optimization and management of all the buildings.

Wiener Netze GmbH is a subsidiary of Wiener Stadtwerke Holding AG (Vienna Municipal Utilities) and is Austria's largest distribution system operator for supplying electricity, gas and district heating. The electrical power mission of Wiener Netze is responsible for customer services, network strategy and planning as well as construction, operation and maintenance of the gas, primary district heating

and electricity grid. Furthermore, Wiener Netze is responsible for meter management, data and regulatory management.

Wien Energie GmbH is a subsidiary of Wiener Stadtwerke Holding AG (Vienna Municipal Utilities) and is responsible for ensuring the reliable supply of electricity, natural gas and heating to the population in the greater Vienna metropolitan area. The utility also is responsible for waste recycling, providing energy–related advice and services, facility management and telecommunications.

Vienna Business agency offers a 360° service for companies in Vienna. Funding and advice, workshops and coaching for startups, assistance with the search for industrial space or office premises, contacts to potential partners in the technology scene or creative industries.

Wien 3420 AG is responsible for ensuring that customers find everything in Seestadt, managing this Smart City. From efficient transport network to complete local supply. All connections for land as well as a logistics center for sustainable, efficient and therefore cost-effective construction.

This collaboration between a technology provider, Siemens, two utilities, Wien Energie and Wiener Netze, a business angel, Vienna Business Agency, and a property manager, Wien 3420, is what makes ASCR unique. It is one of the most innovative and sustainable energy efficiency showcase projects in the world and one which is particularly notable for its exclusivity.

CHAPTER 6: DISCUSSION

This chapter wants to provide an additional contribution to the understanding of how the Open Innovation method is profoundly adopted in the Smart Building industry, identifying behavioral patterns that go beyond the traditional cluster of the previous chapter but are focused more on what kind of knowledge the firms need, their purposes and aims in the market, their customers and their dimensions.

6.1. Findings and Managerial Implications

Once gathered and analyzed all the data in the previous chapter, these have been consequently inspected again to find particular patterns or recurrences between them to respond to the research question. In analyzing these data five variables have been taken into consideration:

- Knowledge/competences acquired: The most important variable that brings the Open Innovation concept with it. As seen deeply in the previous chapters, what bests represent the Open Innovation paradigm is the need and source of knowledge, and with it, competences outside the firm perimeter. Here, the four main purposes that were found in the analysis of data are considered, these bring with them four different competences that are looked for in alliances. The variable divides firms in “offer codevelopment” seeking, “complementary knowledge and competences” seeking, “commercial and operational knowledge” seeking and “increase industry knowledge” seeking. The four categories didn’t want to be touched or rearranged because of their deep connection with the Open Innovation world, their self-explicatory nature and the segmentation of companies that these enables.

- Number of partners in the alliance: To divide firms and their behaviors, the tendency of resorting to a “multi-partners” alliance, consisting in more than two players, of a “single-partner” alliance, where the resorting firms are only two, has taken in consideration. The “multi-partners” alliance per se brings more completeness and a higher integration of

knowledges and competences but it also increases exponentially the complication and the complexity of the alliance, needing more time and resources to be dedicated to overcome barriers, cultural, methodological or market related, and to have all the partners aligned on the final purpose.

- Companies' dimensions: The interviewed companies were in fact very well distributed all along the company lifecycle, from the new-born startup till the huge multinational incumbent, this variable aims at giving a shallow differentiation between them and their range of business. The variable divided the firms in "national", which have business only in Italy, and "international", which have business in Italy but also outside it providing then an indicator of the life cycle and size of companies. Even if all the data have been gathered in the Italian market and for projects held in Italy, this variable has taken into consideration as indicator of the company dimension and of the degree of maturity of its business. To confirm the general trend that the variable describes, the companies' dimensions have been evaluated and confirmed also through the more classical number of employees and revenues factors. For the data about these two features the AIDA databased was used. Defining small firms whose have less than 50 employees and 10 million revenues, medium whose have less than 250 employees and 50 million revenues, and big whose exceed these numbers. The international dimension was confirmed by the whole majority of big firms and a part of the medium. The national one by the small firms and the rest of the medium one. All the data about employees and revenues of all firms are provided in the registry tables present in the annex.

- Partnerships' purpose: This variable tends to better define the partnerships' purpose, dividing it in three sub-categories, "strategic", "operational" or "informative". Partially it recalls the first variable creating a more stringent divisions between the four previously mentioned one, grouping all these partnerships belonging to the different categories that have a shared purpose. The three categories here defined are, in fact, cross boundaries respect to the aforementioned knowledge/competence acquisition variable, and define the ultimate goal of the resorting companies. The strategic one is clearly more long term oriented and aims at creating an improved ecosystem to perform better in the market, while the operational one is aimed at addressing better the market developing competences to

better understand the customers and how to address and reach them, the informative one shows how companies need networks and continuous deep information about the market, its customers, the technologies involved and so on.

- Customers' sector: Last considered variables is the sector which customers belong to. The division was made into three sectors, the "residential" one, characterized by apartment buildings or big independent villas, the "industrial" one, made of factories, production plants, warehouses and other industrial related buildings, and lastly "tertiary", characterized by offices buildings, public administrations one, hotels, retails stores and others. These three different sectors have different needs and must be tackled in different ways; different companies then will undertake different alliances, with different purposes to gain different knowledges also taking in consideration the final customers.

Once defined the five variables taken into consideration the next step is profiling the interviewed firms into these variables and find out behavioral patterns of companies, grouping them to better explain how partnerships occur in the industry.
The behavioral patterns that came out from the analysis of the profiled data are five, that cover all the variables taken into considerations and the interviewed companies.

1. The first notable behavioral pattern observed is given by the deep connection between: the strategic purpose, the resorting to a multiplayer alliance, the search in it for a complementary knowledge or a codevelopment of the offer, the international dimension of companies and the focus on the tertiary sector. The strategic purpose that pushes firms to ally is strictly bond to only two types of knowledge, the complementary and the offer codevelopment ones. It has found that companies will resort, to satisfy this strategic aim, to multiplayer partnerships, to gather complementary competences or codevelop their new offer. The strategic long term horizon is clear in this pattern, how firms want to access and exploit complementary knowledge or work really close to the partners holding these, to create a new, improved and seamless experience for customers that will benefit them and the resorting companies all together. These two sub-variables are causally linked because of their long-term nature and deep involvement that these knowledge-seeking partnerships

aim. The recourse to mainly multiplayers alliances is a clear consequence of the varied and complicated industry; the Smart Building industry is a convergence of different industries that bring with them many specific capabilities. Then the creation of a multiplayers partnership makes sense if the ultimate goal is to co-create new offerings and is a long term commitment, the search of different players enable in fact different perspectives and different capabilities and integrating all those in a seamless ecosystem could be the winning move in the market. The strategic purpose and the high investments, that often these alliances require, bring with them that firms with an international dimension, so usually bigger and more structured, will be more prone to engage in these alliances. Lastly, the predominant customers sector is the tertiary one, due to the always increasing demand for innovative buildings of the sector and the high investments' projects that it fosters. These buildings, being owned by third companies that will profit from them, will demand a very high level of innovation and the "best in the market" services. Moreover, the international nature of the companies present massively in the tertiary sector may push these, international, firms to create partnership investing in a country to then exploit and leverage these worldwide, also for other projects for the same customers.

2. The second behavioral pattern identified is given by the deep connection between: the operational purpose, the resorting to a single player alliance, the search in it for a commercial and operational knowledge, the international dimension of companies and the focus on the tertiary sector. Again, as before there is a clear and strong bonding between two variables, the operational purpose, aim of the partnerships with the commercial and operational knowledges and competences that the firms are looking for. An operational purpose is mainly aimed at reaching and addressing better the market and its customers; then per se it requires a deep and wide commercial and operational knowledge, and capabilities bond to the commercialization of products/services and the operations that those need to be delivered to the final users. This need of a very deep and specific knowledge is also highlighted by the single-player type of alliances that firms resort to. In fact, companies will need many competences on the operational topic but not wide ones. So, these focus on only one specialized company to reach the needed competences, moreover, focusing just on one partner will enable a faster and deeper integration of competences. The international nature of the companies fits this behavioral pattern. In fact, international

companies that perform in many, different markets may not have enough understanding of the single country's competences needed to best act in it, so they need to integrate these through specialized partners. This behavioral pattern is characterized by addressing the tertiary sector too. These can be understood keeping in mind that this sector is the most active and where there are more investments but also for the very wideness of it, that enables many firms to perform and be in the market.

3. The third behavioral pattern identified consists in the deep connection between: the informational purpose, the resorting to a single player alliance, the search in it for an increase in industry knowledge, the national dimension of companies and the focus on the residential sector. The partnerships purpose match again the competences that companies aim at acquiring with the alliances. The purpose of increasing the knowledge of the industry, its customers, the technologies and so on is supported by their strong bond to the national boundaries. In fact, the national dimension of these firms, so, usually, their smallness and smaller business range, is representative of their lower knowledge about the newly converged industry and all the related topics, customers, competitors, technologies, needs and so on. These firms prefer to resort to a single-player partnership, from one side this could be seen as lack of resources to be designated to multi-player's partnerships creation. On the other side, single-partner alliances enable to exploit better and deeper all the needed competences that the partner will provide and to integrate these deeply in the already possessed one. Making alliances with players specialized in information gathering and industry understanding enables the resorting companies to clarify all the dark spots and at the same time creating a big network of practitioners and professionals that can help them later in the future. The national dimension and the focus on the residential sector of these firms is explainable with a higher understanding of the Italian market and its regulations of these companies, that enable them to perform better on the very strict residential sector. The gained knowledge and competences about the industry itself and the very high knowledge of the national market make will permit these to tackle the residential sector of the Italian market effectively in the future.

4. The fourth behavioral pattern identified is made by the deep connection between: both the strategical and operational purposes, the resorting to a single player alliance, the search for complementary knowledge and competences, the national dimension of companies and the focus on the residential sector. This behavioral pattern is pretty similar to the previous one but with the differences that the final purpose of the alliances made in this is both the strategic and operational one, and to pursue this aim companies look for complementary knowledge and competences. This pattern can be understood as the natural evolution of the behavioral pattern described in the third point of this list. The small and with less resources national companies perform in the Smart Building industry successfully too, and to do so they need complementary resources to theirs. This cluster groups both the firms that aim at creating a solid and long-term oriented investment, with the strategic purpose, and the one that are mainly focused in integrating their capabilities with new, operational ones. On one side then, there is the willingness of these national companies to consistently improve their position in the market and invest in partnerships that will create a strategic advantage in the future, on the other there is the willingness of these to better reach the market and achieve these competences that will enable them to create a value added service for customers. The resorting to single-player partnerships is a consequence of a lack of resources to effectively being involved in a multi-player partnership and the need of the two aforementioned purposes of a deep and continuous integration of knowledge and competences that would require too much time if the company would resort to more than one player alliance. Due to the complicacy of having more than one partner to deal with the majority of companies choose the single partner. The reasons that bond the national dimensions of the firms and the focus on the residential sectors have been already shown in the previous point.

5. The fifth and last behavioral pattern identified consists in the deep connection between: the operational purpose, the resorting to a multi-player alliance, the search for commercial and operational knowledge and the focus on the industrial sector. In the final pattern too, the purpose matches perfectly the knowledge that the companies are searching for. The resorting companies, both international and national with no differences between them choose to resort to multi-player partnerships to reach and address better the market and its customers. That per se requires a deep and wide commercial and operational knowledge, and capabilities bond to the commercialization of products/services and the operations that

those need to be delivered to the final users. These firms lack these competences and the only way to develop those, in short times, is partner up. The main difference with the behavioral pattern described in the second point of the list is that in this case firms prefer to choose multi-player alliances instead of single one. A possible explanation of that can reside in the customer sector that in this case is represented by the industrial one instead of the tertiary one. In fact, companies will need many competences on the operational topic but not wide ones for the tertiary one, but for the industrial sectors the huge differences that can exists between warehouses, production plants, factories and the very deep knowledge and competences required in each of them, can led to a lack of competences if is chosen only a single player. Then firms would choose a multi-player alliance to fix this and being able to perform in all the sector indistinctly.

The literature lacks a clear, sectorial understanding of how, why and by which kind of companies is adopted the Open Innovation model in the Smart Building world. The representative examples just provided, and the partnerships found in the previous chapter are an indicator of how OI is the gold standard for innovating and performing in the industry. Moreover, managerial implications arise from the analysis of the gathered data. These start from the increase of awareness of which are the companies' typologies and clusters that tend to alliance most and the main pushing reasons that stand behind these. But, more interesting, are the patterns found in the second part of the analysis and previously described. These in fact show how alliances are not cluster specific but eludes from these and industry belongings, and depends solely on the firms' aims, needed competences and customers, and indirectly by their dimensions. Indirectly how the boundaries of industries are always more blurred and thinner and how convergence destroys these. Since the Smart Building industry is a converged one, all the players acting in this need alliances and to source different, not-owned capabilities, to being able to deliver the needed services and products. The difference stands in the number of players whom they partner with, the moving purpose and aspirations in the market, and the different knowledge that must access.

6.2. Limitations of the Research and Future Developments

As any research this study presents limitations that open many roads to future possible developments. The main limitations regard the data source, their quality and the dimensions of the studied set.

The data gathered to complete this research have been considered enough and quality ones to provide a satisfying and realistic representation of the firms in the market and their activities. Since 51 interviews have been held, all through an open-ended questions' questionnaire that fostered the gathering of many data. But a wider dataset will provide a higher and more specific level of detail and could improve the obtained results and strengthen the results of the analysis, opening also new behavioral patterns that are missing in the research because of the lack of data.

Moreover, the data that were gathered aren't equally distributed in all the clusters. The set present, in fact, a big disequilibrium towards the Technology Providers cluster. This could have given a higher importance to these players and their way of performs and do partnerships in the market. A more equally distributed, in all the clusters, set of data would provide more balanced data and would make easier the identification of behaviors and partnerships types that this research has not considered for lack of data, increasing the weight of these patterns that have been neglected because not highly recurrent, or because of their niche nature. Due to the limited dataset and their unbalance through all the clusters some partnerships that have been found in some groups don't find correspondence in the other involved, causing misleading understandings. These are only due to data unbalance and to the higher presence of companies in a cluster than in another, and could be solved increasing the number of interviews and aiming at an equal number of interviewed firms per cluster.

The new enlarged and improved dataset will be the best platform to explore other patterns and go more in depth of the new and the here found ones.

This will enable to go more in depth with the analysis exploring new angles such as the different governance methods that the alliances will present, and their correlations with the competences needed, and the different aims and purposes of the different firms, which it has not been possible with the current data.

Another limitation is due to the method used to gather the data used, the interviews.

Interviews, even being a fresh and direct source of information, could also have caused biased information, and these may have generated not high-quality data to work with. This is caused by

the possibility that some questions give quite some space to free interpretation of the questions itself, or could be not completely understood by the interviewed leading to bad responds or to misunderstood ones, that inevitably caused biased data and that then afflicted the final results.

As variable used to profile the companies has been used the international or national dimension of companies as indicator of their dimensions and their business dimensions. These, even if there is a recurrence between this dimension and the life cycle and size of companies, is not the best possible choice. There are, in fact, some well-known cases that fall outside this relation between internationalization and firms' dimensions, such as the born global firms or some particular niche family firms, then this could have created some weak spot in the research.

Lastly the data were gathered only in the Italian market and only for projects held in Italy. This focus only on the Italian market does not assure results generalizability in all the other countries. A possible angle for future research should be testing the robustness of this thesis' results at a cross county international level.

CHAPTER 7: CONCLUSIONS

This chapter wants to sum up all the findings listed all across the thesis to remind the readers and to give a clearer overall image of the results.

From the first analysis of the data the most common alliances of the set fund were.
The two leading categories are the partnerships between software and technology providers and the alliances of firms with vendors, system integrators and installers. The leading position of the first one is a clear exemplification of how the technological, physical world and the IT based one need and must be in close contact in the Smart Building environment. Considering the latter, it's clear then how these partnerships' purpose is the access to commercialization and installation capabilities. Then follow the partnerships with the firms belonging to the same cluster. So, for example, alliances between two different technology providers. The numerous technologies and services needed inside a Smart Building can, in fact, bring competitors to cooperate, focusing on different products or services, or different parts of the value chain. Following there are two different categories: alliances between technology providers and plant engineering studios and alliances between firms and universities, research centers, innovative startups. The need of a strong integration between technologies and the various systems needed in the building (wiring, heating, monitoring, automation systems) is the roots of the first collaborations. Regarding the second category, different firms are moved by reasons such increasing the knowledge of the market, the industry and the operating companies or technology access and acquisition to create these alliances. Following the partnerships between ESCOs and technology providers represent the need of both companies to codevelop their offers integrating ESCOs' energy services with the technology providers' energy related technologies (HVAC systems, lighting), to create the most fluid and easy to use environment. The partnerships between general contractors and technology providers present the need of a codeveloped offer since the very beginning of the projects. The last set

consists in the partnerships between utilities and software providers. This pattern shows the need of customized software and IT services ad hoc per each building, projects.

Regarding the main pushing reasons, so the lacking competences that the firms were looking for. **Complementary knowledge and resources**. It's the most researched knowledge of the set. The convergence of the industry makes fundamental the access to complementary technologies since the competences belonging to just one traditional sector aren't enough anymore. This purpose is very close to the co-development of the offer one, but it can imply less interaction and involvement level of the two companies; in fact, differently from the latter the two companies can interact as standalone entities that resort to licensing to give access to one to the missing technologies and knowledges. **Commercial and operational knowledge.** This knowledge is about the general understanding of the market, the customers presence in it and how to better reach them and interact with them, being able to provide all these accessories' services that go beyond the selling of the products/services. Most of the times the operational purpose is very bond to the commercial one. Their shared characteristic is that they both have a practical purpose; not aimed at investing resources into creations of new, improved offers for customers, but to more effectively and efficiently address the market. **Codevelopment of the offers.** This purpose is close to the access to complementary knowledge and competences; that the convergence of the industry makes fundamental to access. The co-development of the offer is a direct consequence of this; the high specificity of knowledge and competences and the need of a deep, strong integration between them crave the joint development of services and products, to create a more fluid and seamless experience for the final users. This goes more in dept than access to complementary knowledge and competences, since the nature is more of co-creation and joint provision of services. **Increasing industry knowledge.** This purpose is mostly reached by alliances with universities and research centers or consultants. These in fact are a huge source of fresh information about the market, its main players, the technologies involved, the main trends, its customers and so on. Moreover, these actors can also boost a firm's networks of knowledge, putting it in contacts with practitioners, external consultants, other firms operating inside the university, small innovative startups.

Last but not least important, the most interesting result were given by the analysis of the data all grouped and not divided. These, in fact, showed five cross industries behavioral patterns and how the boundaries of industries are always more blurred and thinner. These are an example of how companies don't choose the partners on the basis of the belonging industries but on their aims in

the market, the needed competences and their customers mainly. The first behavioral pattern observed is given by the deep connection between: the strategic purpose, the resorting to a multiplayer alliance, the search in it for a complementary knowledge or a codevelopment of the offer, the international dimension of companies and the focus on the tertiary sector. The strategic purpose that pushes firms to ally is strictly bond to only two types of knowledge, the complementary and the offer codevelopment ones. It has found that companies will resort, to satisfy this strategic aim, to multiplayer partnerships, to gather complementary competences or codevelop their new offer. The strategic purpose and the high investments, that often these alliances require, bring with them that firms with an international dimension, so usually bigger and more structured, will be more prone to engage in these alliances. Lastly, the predominant customers sector is the tertiary one, due to the always increasing demand for innovative buildings of the sector and the high investments' projects that it fosters. The second behavioral pattern identified is given by the deep connection between: the operational purpose, the resorting to a single player alliance, the search in it for a commercial and operational knowledge, the international dimension of companies and the focus on the tertiary sector. There is a clear and strong bonding between two variables, the operational purpose, aim of the partnerships, with the commercial and operational knowledges and competences that the firms are looking for. This need of a very deep and specific knowledge is also highlighted by the single-player type of alliances that firms resort to. International companies that perform in many, different markets may not have enough understanding of the single country's competences needed to best act in it, so they need to integrate these through specialized partners. This behavioral pattern is characterized by addressing the tertiary sector too. The third behavioral pattern identified consists in the deep connection between: the informational purpose, the resorting to a single player alliance, the search in it for an increase in industry knowledge, the national dimension of companies and the focus on the residential sector. The purpose of increasing the knowledge of the industry, its customers, the technologies and so on is supported by their strong bond to the national boundaries. In fact, the national dimension of these firms, so, usually, their smallness and smaller business range, is representative of their lower knowledge about the newly converged industry and all the related topics, customers, competitors, technologies, needs and so on. These firms prefer to resort to a single-player partnership, from one side this could be seen as lack of resources to be designated to multi-player's partnerships creation. On the other side, single-partner alliances enable to exploit better and deeper all the needed competences that the partner will provide and to integrate these deeply in the already possessed one. The fourth behavioral

pattern identified is made by the deep connection between: both the strategical and operational purposes, the resorting to a single player alliance, the search for complementary knowledge and competences, the national dimension of companies and the focus on the residential sector. This pattern can be understood as the natural evolution of the behavioral pattern described before. The small and with less resources national companies perform in the Smart Building industry successfully too, and to do so they need complementary resources to theirs. This cluster groups both the firms that aim at creating a solid and long-term oriented investment, with the strategic purpose, and the one that are mainly focused in integrating their capabilities with new, operational ones. Due to the complicacy of having more than one partner to deal with the majority of companies choose the single partner. The fifth and last behavioral pattern consists in the deep connection between: the operational purpose, the resorting to a multi-player alliance, the search for commercial and operational knowledge and the focus on the industrial sector. The resorting companies, both international and national with no differences between them choose to resort to multi-player partnerships to reach and address better the market and its customers. The main difference with the behavioral pattern described in the second point of the list is that in this case firms prefer to choose multi-player alliances instead of single one. A possible explanation of that can reside in the customer sector that in this case is represented by the industrial one instead of the tertiary one.

CHAPTER 8: LIST OF REFERENCES

Ahn J., Minshall T., Mortara L. (2015). *"Open innovation: a new classification and its impact on firm performance in innovative SMEs."* Journal of Innovation Management, 3 (2), 33-54.

Ahonen M., Antikainen M., Mäkipää M. (2007). *"Supporting collective creativity within open innovation."* Proceedings of the European Academy of Management (EURAM) Conference, 1-18, Paris, France.

Armbrust M., Fox A., Griffith R., Joseph A. D., Katz R., Konwinski A., Lee G., Patterson D., Rabkin A., Stoica I., Zaharia M. (2010). *"A View of Cloud Computing."* Communications of the ACM.

Arora A. and Fosfuri A. (2003). *"Licensing the market for technology."* Journal of Economic Behavior and Organization, 52 (2), 277-95.

https://www.aspern-seestadt.at/

Aspern Smart City Research, Energy research shaping the future of energy. https://www.ascr.at

Bader K., Enkel E. (2014). *"Understanding a firm's choice for openness: strategy as determinant."* Journal of Technology Management, 66 (2/3), 156-181.

Belderbos R., Carree M., Diederen B., Lokshin B., Veugelers R. (2004). *"Heterogeneity in R&D cooperation strategies."* International Journal of Industrial Organization, 22, 1237-1263.

Bianchi M., Campodall'Orto S., Frattini F, Vercesi P. (2010). *"Enabling open innovation in small and medium-sized enterprises: how to find alternative applications for your technologies."* R&D Management, 40 (4), 414-431.

Bianchi M., Cavaliere A., Chiaroni D., Frattini F., Chiesa V. (2011). *"Organizational modes for Open Innovation in the bio-pharmaceutical industry: An explanatory analysis."* Technovation, 31, 22-33.

References

Bianchi M., Croce A., Dell'Era C., Di Benedetto A., Frattini F. (2016). *"Organizing for Inbound Open Innovation: How External consultants and a Dedicated R&D Unit Influence Product Innovation Performance."* Journal of Product Innovation Management, 33 (4), 492-510.

Bogers M., Chesbrough H., Moedas C. (2018). *"Open Innovation: Research, Practices, and Policies."* California Management Review, 60 (2), 5-16.

Bonneau V., Ramahandry T., Probst L., Pedersen B., Dakkak-Arnoux L. (2017). *"Smart Building: Energy efficiency application."* Digital Transformation Monitor. https://ec.europa.eu/growth/tools-databases/dem/

https://www.breeam.com/case-studies/offices/the-edge-amsterdam/

Bröring S. (2010). *"Developing innovation strategies for convergence – is 'open innovation' imperative?"* International Journal of Technology Management, 49 (1/2/3), 272-294.

Buntz B. (2016). *"Meet Austria's Smart City of the future."* IoT World Today.

Caetano M., Amaral D.C. (2011). *"Roadmapping for technology push and partnership: A contribution for open innovation environments."* Technovation, 31, 320-335.

Candi M., van den Ende J., Gemser G. (2016). *"Benefits of Customer Codevelopment of New Products: The Moderating Effects of Utilitarian and Hedonic Radicalness."* Journal of Product Innovation Management, 33 (4), 418-434.

Chesbrough H., Lettl C., Ritter T. (2018). *"Value Creation and Value Capture in Open Innovation."* Journal of Product Innovation Management, 35 (6), 930-938.

Chesbrough H., Vanhaverbeke W., West J. (2006). *"Open Innovation: Researching a New Paradigm."* Oxford University Press.

Chiaroni D., Chiesa V., Frattini F. (2010). "*Unravelling the process from Closed to Open Innovation: evidence from mature, asset-intensive industries."* R&D Management, 40 (3), 222-245.

"Chorus Life Magazine" Chorus Lifestyle Magazine, autorizzazione tribunale di Bergamo n. 01/19 del 14.02.2019. Quadrimestrale Giugno 2019 N.002.

http://www.choruslife.com/it/home.asp

References

Costanzo E., Martino A., Varalda G., Antinucci M., & Federici A. (2017). "*EPBD implementation in Italy."*

Cricell L., Greco M., Grimaldi M. (2016). "*Assessing the open innovation trends by means of the Eurostat Community Innovation Survey."* International Journal of Innovation Management, 20 (3), 1-30.

Dahlander L., Gann D.M. (2010). *"How open is innovation?"* Reseach Policy, 39, 699-709.

De Mauro A., Greco M., Grimaldi M. (2016). *"A Formal Definition of Big Data Based on its Essential Features."* Emeral Group Publishing Limited.

Dell'Era C., Verganti R. (2010). *"Collaborative Strategies in Design-intensive Industries: Knowledge Diversity and Innovation."* Long Range Planning, 43, 123-141.

Eisenhardt K.M., Graebner M.E. (2007). *"Theory building from cases: opportunities and challenges."* Academy of Management Journal, 50 (1), 25-32.

European Commission. (2018, September 04). "*Developing a Smart Readiness Indicator for buildings: the final report commissioned by DG ENERGY*." Tratto da The European Portal for Energy Efficiency in Buildings: https://www.buildup.eu/en/practices/publications/developing-smart-readiness-indicator-buildings-final-report-commissioned-dg

European Commission. (2019). "*Energy performance of buildings: long-term renovation strategies*." Tratto da European Commission: policies, information and services: https://ec.europa.eu/energy/en/topics/energy-efficiency/energy-performance-of-buildings/long-term-renovation-strategies

European Commission. (2019). "*EU Building Stock Observatory*." Tratto da Energy performance of buildings: EU Building Stock Observatory: https://ec.europa.eu/energy/en/topics/energy-efficiency/energy-performance-of-buildings/eubuildings

European Commission. (2019). "*The Energy Performance of Buildings Directive."* Tratto da European Commission: policies, information and services: https://ec.europa.eu/energy/sites/ener/files/documents/buildings_performance_factsheet.pdf

References

Fisher D., DeLine R., Czerwinski M., Drucker S. (2012). *"Interactions with Big Data Analytics."* Association for Computing Machinery (ACM).

Fletcher R., Santhanam N., & Varanasi S. (2018). "*Laying the foundation for success in the connected-building era."* McKinsey Global Institute.

Fosfuri, A. (2006) *"The licensing dilemma: understanding the determinants of the rate of technology licensing."* Strategic management Journal, 27, 1141–1158.

Gambardella A., Giuri P. and Luzzi A. (2007). *"The market for patents in Europe."* Research Policy, 36, 1163–1183.

Gambardella A., Panico C. (2014). *"On the management of open innovation."* Research Policy, 43, 903-913.

Garcia R., Calantone R. (2002). *"A critical look at technological innovation typology and innovativeness terminology: a literature review."* Journal of Product Innovation Management, 19, 110-132.

Gassmann O., Enkel E. (2004). *"Towards a Theory of Open Innovation: Three Core Process Archetypes."* R&D Management Conference (RADMA), 1-18, Lisbon, Portugal.

Gassmann O., Enkel E., Chesbrough H. (2010). *"The future of open innovation."* R&D management, 40 (3), 213-221.

Grimaldi M., Corvello V., De Mauro A., Scarmozzino E. (2017). *"A systematic literature review on intangible assets and open innovation."* Knowledge Management Research & Practice, 15 (1), 90-100.

Greer C.R., Lei D. (2012). *"Collaborative Innovation with Customers: A Review of the Literature and Suggestions for Future Research."* International Journal of Management Reviews, 14, 63-84.

Grönlund J., Sjödin D.R., Frishammar J. (2010). *"Open Innovation and the Stage-Gate Process: A Revised Model for New Product Development."* California Management Review, 52 (3), 106-131.

Gudivada V. N., Baeza-Yates R., Raghavan V.V. (2015). *"Big Data: Promises and Problems."* IEEE computer society.

References

Holdowsky J., Mahto M., Raynor M. E., & Cotteleer M. (2015). "*Inside the Internet of Things (IoT).*" Deloitte University Press.

He D., Orzoco S., Straus M., Kovalenko N., Remezkova V. (2015). *"Being a smart city: the case of Vienna and Seestadt Aspern."*

Hu Y., McNamara P., McLoughlin D. (2015). *"Outbound Open Innovation in bio-pharmaceutical out-licensing."* Technovation, 35, 46-58.

Jalia A., Bakker R., Ramage M. (2018). *"The Edge, Amsterdam. Showcasing an exemplary IoT building."* University of Cambridge.

Jeon J., Lee C., Park Y. (2011). *"How to Use Patent Information to Search potential Technology Partners in Open Innovation*." Journal of Intellectual Property Rights, 16, 385-393.

Kovacs A., Van Looy B., Cassiman B. (2015). "*Exploring the scope of open innovation: a bibliometric review of a decade of research*." *Scientometrics*, 104 (3), 951–983.

Kutvonen A. (2011). *"Strategic application of outbound open innovation."* European Journal of Innovation Management, 14 (4), 460-474.

Leitão J. (2018). *"Open Innovation Business modeling."* Contributions to Management Science, Springer.

Lichtenthaler U. (2008). *"Open Innovation in Practice: An Analysis of Strategic Approaches to Technology Transactions."* IEEE Transactions on Engineering Management, 55 (1), 148-157.

Lichtenthaler U., (2009). *"Outbound open innovation and its effect on firm performance: examining environmental influences."* R&D Management, 39 (4), 317-330.

Lichtenthaler U. (2015). *"A note on outbound open innovation and firm performance."* R&D Management, 45 (5), 606-608.

Mell P., Grance T. (2011). *"The NIST Definition of Cloud Computing."* NIST, National Institute of Standards and Technology.

References

Meulman F., Reymen I.M.M.J., Podoynitsyna K.S., Romme A.G.L. (2018). *"Searching for Partners in Open Innovation Settings: How to Overcome the Constraints of Local Search."* California Management Review, 60 (2), 71-97.

Ministero dello Sviluppo Economico. (2015, June 26). "*Decreto interministeriale 26 giugno 2015 - Applicazione delle metodologie di calcolo delle prestazioni energetiche e definizione delle prescrizioni e dei requisiti minimi degli edifici."* Tratto da https://www.mise.gov.it/index.php/it/normativa/decreti-interministeriali/2032966-decreto-interministeriale-26-giugno-2015-applicazione-delle-metodologie-di-calcolo-delle-prestazioni-energetiche-e-definizione-delle-prescrizioni-e-dei-requisiti-minimi-degli

Ministero dello Sviluppo Economico. (2019, April 12). "*Incentivi impresa: Iper e Super Ammortamento*." Tratto da Ministero dello Sviluppo Economico: https://www.mise.gov.it/index.php/it/incentivi/impresa/iper-e-super-ammortamento

Mortara L., Minshall T. (2011). *"How do large multinational companies implement open innovation?"* Technovation, 31, 586-597.

Ojasalo J., Kauppinen H. (2016). *"Collaborative Innovation with External Actors: An Empirical study on Open Innovation Platforms in Smart Cities."* Technology Innovation Management Review, 6 (12), 49-60.

Osservatorio IoT. (2019). *"Smart Home: cresce il mercato, evolvono le abitudini dei consumatori italiani."* Politecnico di Milano.

Osservatorio IoT. (2019). "*Smart Home: senti chi parla!"* Politecnico di Milano.

Perkmann M., Walsh K. (2007). *"University-industry relationships and open innovation: Towards a research agenda."* International Journal of Management Reviews, 9 (4), 259-280.

Pieper C., Maciel J., de Laubier R., Wunder M., & Metzdorf A. (2018). "*A Guide to the Revolution in Smart Buildings."* The Boston Consulting Group.

Piller F.T., Walcher D. (2006). *"Toolkits for idea competitions: a novel method to integrate users in new product development."* R&D Management, 36 (3), 307-318.

References

Pisano G.P., Verganti R. (2009). *"Which Kind of Collaboration is Right for You?"* Harvard Business Review, 1-7, December 2008.

Primo M.A.M., Amundson S.D. (2002). *"An exploratory study of the effects of supplier relationships on new product development outcomes."* Journal of Operations Management, 20, 33-52.

PwC's Innovation Benchmark. "*Reinventing innovation. Five findings to guide strategy trough execution."* www.pwc.com/innovation-benchmark

Randall T. (2015). *"The Smartest Building in the World. Inside the connected future of architecture."* Bloomberg, 23 September 2015.

Sagiroglu S., Sinanc D. (2013). *"Big Data: A Review."* IEEE computer society.

Saebi T., Foss N.J. (2015). *"Business models for open innovation: Matching heterogeneous open innovation strategies with business model dimensions."* European Management Journal, 33, 201-213.

Salter A., Criscuolo P., Ter Wal A.L.J. (2014). *"Coping with Open Innovation: responding to the challenges of external engagement in R&D."* California Management Review, 56 (2), 77-94.

Schartinger D., Rammer C., Fischer M.M., Fröhlich J. (2002). *"Knowledge interactions between universities and industry in Austria: sectoral patterns and determinants."* Research Policy, 31, 303-328.

"Schneider Electric helps make The Edge among "the world's most sustainable" office buildings." Schneider-Electric.com/ecostruxure-building.

Schuster A., Richter B. (2019) *"Vienna Smart City Pilot Project. Early results in residential areas offer an opportunity to avoid repetition of unbalanced loading and instability issues in future installations."* Transmission and distribution world.

"Smart Building Market 2018 Global Trends, Market Share, Industry Size, Growth, Opportunities and Forecast to 2023." Reuters, September 10, 2018.

"Smart Building technology development. A systematic approach to enhancing operational efficiency and occupant experience." PwC, 2019.

References

"Smart City Vienna, What's the strory? Some initial response from Aspern Seedstat". https://www.aspern-seestadt.at/

"Solutions for the future of energy in open space." https://smartcity.wien.gv.at/site/en/aspern-smart-city-research/

Strafaci A. (2008). *"What does BIM mean for civil engineers?"* CENews.com, 30 September 2008, http://www.cenews.com/article.asp?id=3232.

Sundgren M., Dimenäs E., Gustafsson J.E., Selart M. (2005). *"Drivers of organizational creativity: a path model of creative climate in pharmaceutical R&D."* R&D management, 35 (4), 359-374.

Teece D.J. (1998). *"Capturing value from knowledge assets: the new economy, markets for know-how, and intangible assets."* California Management Review, 40, 55–79.

Tether B.S. (2002). "*Who co-operates for innovation, and why. An empirical analysis."* Research Policy, 31, 947-967.

"The status of open innovation in Europe. Corporate-startup collaboration." Startup Europe Partnership, 2018. http://startupeuropepartnership.eu

Verganti R. (2008). *"Design, Meanings and Radical Innovation: A Metamodel and a Research Agenda."* Journal of Product Innovation Management, 25, 436-456.

Weaver B. (2007). *"Research proposal: Industry convergence – Driving forces, factors and consequences."* Paper presented at the 19th Business Administration Conference (NFF), 1-20, Bergen, Norway.

Wellener P., Michalik J., Ashton Manolian H., & James G. (2018). "*Smart buildings: four considerations for creating people-centered smart, digital workplaces*." Deloitte Insights.

West J., Bogers M. (2014). *"Leveraging External Sources of Innovation: A Review of Research on Open Innovation."* Journal of Product Innovation Management, 31 (4), 814-831.

West J., Salter A., Vanhaverbeke W., Chesbrough H. (2014). "*Open Innovation: The next decade."* Research Policy 43, 805-811.

References

"Why are smart buildings important? The safe option for sustainable business growth." Thought Leadership from BLM.

Wortmann F., Flüchter K. (2015). *"Internet of Things. Technology and Value Added."* Springer Fachmedien Wiesbaden.

ANNEX

Hereafter the registry tables of the interviewed companies are listed, the descriptions and data were gathered during the interviews, or found in the companies' website. About the data that regards revenues or employees, for Italian companies has been used the AIDA database, while for international companies the financial results and employees have been found in the companies' website.

LOGO	NAME	INDUSTRY	DESCRIPTION	REVENUES	NUMBER OF EMPLOYEES	HEADQUARTER
	ALPERIA	ESCo	Offers domotic systems on thermal station, control, monitoring and automation. Offering energy performance contract	1.162 billions €	132	Bolzano, Italy
	AVVENIA	ESCo	ESCo that works only with big players offering monitoring and consulting servicies, though an associated platform that is able to analyze and manage remotely the consumption.	20 millions €	15	Roma, Italy
	EDILVI spa	ESCo	Small ESCo that produces NZEB-buildings. Though air and electric IT system, connected to the weather previsions that is able to transform the electric energy into thermic energy.	1.3 millions €	12	Viltorba, TV, Italy
	ENERGY WAVE	ESCo	They provide energy efficiency servicies and provision of electric energy and gas	17 millions €	117	Spinetta Marengo, AL, Italy
	ENERSOLARE	ESCo	Offers automation and energy efficiency services.	800,000 €	11	Mandatoriccio, CS, Italy
	GBSOLS	ESCo	ESCo focused on the SME firms, offering monitoring, energy efficiency servicies and thermoregulation products.	800,000 €	4	San Donato Milanese, MI, Italy
	MP NEXT	ESCo	Offers solutions aimed at reducing the cost of energy and the purchase of energy from buildings improving the energy efficiency. Though heath pump and boilers remotely controlled.	2 millions €	5	Como, Italy
	SACEE	ESCo	ESCo focused on the industrial and commercial sector. They deal with energy management, data management for predictive maintenance and remote energy efficiency	2 millions €	5	Milano, Italy
	ARCOSERVIZI	Facility Management	Company that offers energy diagnosis services, manitenance of plants and buildings	16 millions €	52	Torino, Italy
	SIRAM	Facility Management	Creates energy efficiency projects, cogeneration and remote heating, using also renovables technologie. Aims at the reduction of consumptions and costs.	506 millions €	2,134	Milano, Italy
	CPL CONCORDIA	Facility Management	Aims at improving the comfort and quality of lives of people using efficient technologies. Providing gas, energy, IT solutions all remoted monitored	244 millions €	1,242	Concordia, MO, Italy
	DE GIORGI GLOBAL SERVICE	Facility Management	Facility management company that provides energy efficiency consultancy servicies	1.3 millions €	19	San Donato di Lecce, LE, Italy
	FOCCHI	General Contractor	Firm that designs, realizes and installs architectural projects such as facades and external coverings.	500,000 €	0	Poggio Torriana, RM, Italy
	ELMEC SOLAR	Software Provider	Provides softwares dedicated to the users' productivity, tools for the safety and compliance of all the work stations and the relative infrastructure.	7 millions	11	Brunello, VA, Italy
	AMB SOLUTIONS	Software Provider	Provides softwares for the integrations of differnet communication protocols and different technological products enabling the plant integrations and remote control of them	400,000 €	5	Vimercate, MB, Italy
	ENERGISME	Software Provider	Provides software, Saas, to gather provision of gas, heating, light data highly integrable with the custoemers products to have a real time monitoring of the situation			
	RICOH	Software Provider	Provides softwares for the improvement of productivity, to simplify the workload flows, reduce the costs, facilitate the job and improve the documents safety	16 billions €	93,000	Ōta, Japan
	IBM	Software Provider	Huge multinational that have a very wide portfolio of softwares' offers, form the analytics and cloud servicies till to blockchain, IoT and artificial intelligence, Watson.	72 billions €	381,100	Armonk, USA
	MICROSOFT	Software Provider	It's a huge American multinational software provider that develops, and sells mainly computer software, cloud platforms and analytics services, such as Azure, an ever-expanding platform of cloud computing services. Also active in the area of consumer electronics, personal computers and related services.	115 billions €	114,000	Redmond, USA

	CEAS MILANO	Plant Engineering Studio	Designs and installs an integrated plants and products. Being present form the beginning of the project till its ending.	2.8 millions €	13	Milano, Italy
	TEON srl	Plant Engineering Studio	Provides heating and cooling systems for residential, commercial and industrial sectors	150,000 €	1	Monza, Italy
	ELETTROMECCANICA GALLI	Plant Engineering Studio	Designs and installs elettrical, telecomunications, data transmission, videosurveillance and thermo-hydraulic plants for the industrial and commercial sectors	40 millions €	161	Erba, CO, Italy
	F&M INGEGNERIA	Plant Engineering Studio	Provides many servicies such as architectural, structural and BIM design, plant design and installation	9 millions €	49	Mirano, VE, Italy
	STC	Plant Engineering Studio	Engineering company specialized in consulting and design of technological plants. Such as elettrical, HVAC, solar, automotive, safety and videosurveillance and so on	1.6 millions €	13	Peraga di Vigonza, PD, Italy
	STT	Plant Engineering Studio	Studio specialized in the design and consulting for termotechnical plants HVAC. Both for the residential and in the industrial sector	300,000 €	3	Milano, Italy
	ABB	Technology Provider	Huge multinational company that operates all across the world. Provides many products that cover all the VP proposed by the SB industry. Such as property safety products, automations products and eneragy management ans distribution products.	25.1 billions €	147,000	Zurich, Switzerland
	ACOTEL	Technology Provider	Company that offers products and a platform for the automation and the management consulting for the building. In particular automation and automatization of the monitoring and safety system, energy monitoring, and remote management of the whole building	7.2 millions €	36	Rome, Italy
	ALPITEL	Technology Provider	System Integrator company that integrates solutions for the structured wiring, optical fiber and connectivity in general. Provides Cloud solutions such PaaS enabling the remote monitoring and control of all the products integrated with the platform.	78 millions €	655	Nucetto, CN, Italy
	AVE spa	Technology Provider	Company that offers professionals domotic systems with integrated hardware and software	28 millions €	179	Virle, BS, Italy
	BECKHOFF	Technology Provider	Multinational family based company that sell sensors, hardware and software integrated for the automation and control of industrial plants. Their system is open interoperable and customizable.	916 milion €	3,900	Verl, Germany
	BTICINO	Technology Provider	Big multinational that provide numerous products for the residential automation and domotic. Their MyHome is an ecosystem that enables through the interconnession with all the connected products a delivery of all the VP proposed in the industry and the remote management of all the processes and products.	800 millions €	2,768	Varese, Italy
	DANFOSS	Technology Provider	Huge Danish multinational that produces and sells compnets for the climatization control, heating, HVAC and valves. That aim at strong integrability, comfort mazimization and energy efficiency.	3.2 billions €	24,000	Nordborg, Denmark
	EMERSON	Technology Provider	Big group with an international presence focused on the refrogeration and HVAC of the food retail sector. They offer form the design of the system to the managent and remote monitoring of data.	17.5 billions €	76,500	Saint Louis, USA
	ENSTO	Technology Provider	Family Finnish multinational that provides electrical solutions for buildings, its handling and efficiency. Selling control statins for all the plugs, lights and electrical heating in the building.	266 millions €	1,600	Porvoo, Finland
	GEMINO	Technology Provider	Start up born in 2010 that produce sensors and automation products and a platform to handle many services; such as energy efficiency, monitoring and control of their connected products or others'.	400,000 €	3	Milano, Italy
	GEWISS	Technology Provider	Offers products for the buildings automation, smart lightining, smart products for the protection and efficiency of the electric system.	300 millions €	1,028	Cenate Sotto Bergamo, BG, Italy
	HAGER-BOCCHIOTTI	Technology Provider	International group that produces products for the distribution, energy wiring and building automation all interconnected through a connex platform.	1.9 billions €	11,400	Blieskastel, Germany
	HONEYWELL	Technology Provider	Big technological multinational that offers products for the building automation, such as wiring and automation systems to make smart the building.	38 billions €	130,000	Morristown, USA
	KONE	Technology Provider	Elevator and more in general people flow management products/services provider.	9 billions €	55,000	Espoo, Finland
	MAETRICS	Technology Provider	Small company that offers smart solutions for the energy management and the building automation. Providing Cloud solutions and IoT platforms aimed at control and management of lighting, HVAC, safety and security systems.	700,000 €	3	Marghera, VE, Italy
	OTIS	Technology Provider	Elevator and escalator provider. Their top smart product is Compass, a smart sorting system where the elevators group people that go to the same, close, floors to reduce energy consumption and improve the service.	11.4 billions €	68,000	Farmingtown, USA
	SCHINDLER	Technology Provider	Lift and escalators provider. Offering smart elevators remotely monitored thorugh app or dashboard and with an infotainment system on board.	9.61 billions €	64,000	Ebikon, Switzerland

Annex

	SCHNEIDER	Technology Provider	Leader of the Italian market and one of the biggest worldwide, they have a numerous number of products that cover all the different VP in the SB industry	25.72 billions €	136,000	Rueil-Malmaison, France
	SIEMENS	Technology Provider	Big multinational operating in the system and software field. Offers a wide portfolio of products, systems and solutions for the realization of buildings automation systems, HVAC, micro & smart grid. All basd on IoT techhnology and Cloud solutions.	83.05 billions €	372,000	Munich, Germany
	VIMAR	Technology Provider	Italian company that offers electronic products for the smart management of buildings. Such as; plugs, switches, alarms, security cameras and others all integarted and manageble form an online platform.	222 millions €	1,059	Marostica, VI, Italy
	WITTUR	Technology Provider	Supplier of components for elevator companies. Provide smart components compliant with the safety and the predictive maintenance.	800 millions €	4,500	Wiedenzhausen, Germany
	FASTWEB	TELCO	Multinational telco that offers many communication servicies, cloud computing, data housing and software servicies.	2.1 billions €	2,585	Milano, Italy
	TIM	TELCO	Italian telco that offers in italy and worldwide telecommunication, internet and television servicies.	14 billions €	40,806	Milano, Italy
	VODAFONE	TELCO	Huge multinational telco that operates worldwide. The company offers a platform that is able to develop different solutions based on the customers' needs, such as intelligent monitoring, energy efficiency, access management.	43.67 billions €	98,996	Newbury, UK
	EDISON	Utility	Italian utility providing servicies of monitoring, efficiency and management of the system, depending on the digitalization degree of the system.	7 billions €	1,380	Milano, Italy
	ENEL X	Utility	Born from Enel, it represent the smart part of the company. Their idea is trasforming energy in new opportunities, using Energy as a service. They provide a platform, energy cloud system, to connect hurban ecosystems, industrial plants and mobility needs.	428 millions €	1,300	Boston USA

Hereafter is provided the questionnaire that supported all the interviews that have been made

Questionario Smart Building Report 2019 – Energy & Strategy

Il presente questionario ha l'obiettivo di raccogliere informazioni utili per esaminare i modelli di business con cui i principali operatori del settore stanno offrendo (o intendono offrire in futuro) prodotti e servizi per il settore degli Smart Building.

Il questionario è articolato in 4 sezioni: (1) Dati Generali, in cui vengono raccolte informazioni circa il vostro giro d'affari nel mercato dello Smart Building e la vostra percezione circa le dimensioni complessive e le prospettive di sviluppo del mercato dello Smart Building in Italia (2) Business Model, in cui vengono raccolte informazioni circa il business model (prodotti/servizi/soluzioni per lo Smart Building che offrite, segmenti di mercato target, partnership su cui si basa il vostro modello di business) attuale ed in ottica prospettiva (3) Investimenti e Strategia, in cui vengono raccolte informazioni circa i vostri investimenti nel settore dello Smart Building e sui vostri principali competitor (4) Normativa, in cui vengono raccolte informazioni circa le principali norme, sistemi di incentivazione e di obbligo che stanno influenzando o promuovendo lo sviluppo del mercato dello Smart Building in Italia.

I dati raccolti verranno trattati in forma anonima e saranno aggregati per fornire indicazioni di tendenza e trend prospettici.

Le analisi effettuate su questi dati ed i principali risultati della ricerca saranno raccolti nello Smart Building Report (SBR) 2019, che verrà presentato ad inizio 2020 presso il Politecnico di Milano.

Annex

La definizione di Smart Building che viene adottata nello SBR 2019 è la seguente:

Smart building are digitally connected structures that combine optimized building and operational automation with intelligent space management to enhance the user experience, increase productivity, reduce (energy) costs, and mitigate physical and cybersecurity risks.

Vi ringraziamo per la gentile disponibilità.

Team Energy & Strategy – Smart Building Report 2019

PARTE 1: Dati Generali

- Qual è il vostro giro d'affari che è riconducibile a prodotti/servizi/soluzioni per lo Smart Building nel 2018?
- Come è suddiviso il vostro giro d'affari tra edifici residenziali, terziario privato, terziario pubblico, ed edifici industriali?
- Quanto vi attendete che questo vostro giro d'affari crescerà ogni anno (percentualmente) nei prossimi 5 anni?
- Come vi siete strutturati per offrire prodotti/servizi/soluzioni per lo Smart Building? Sono prodotti/servizi/soluzioni integrati nella vostra offerta attuale? Avete costituito un team o un'unità organizzativa dedicati?
- Quanti dipendenti (o FTE) sono coinvolti nello sviluppo e vendita dei prodotti/servizi/soluzioni per lo Smart Building?
- Sapreste quantificare (o stimare a grandi linee) il mercato italiano dei prodotti/servizi/soluzioni per lo Smart Building nel 2018?
- Quanto vi aspettate che questo mercato possa crescere ogni anno (percentualmente) nei prossimi 5 anni?

PARTE 2: Business model

Value Proposition

- Qual è l'insieme dei prodotti/servizi/soluzioni per lo Smart Building che offrite attualmente sul mercato?
- Qual è la value proposition con cui questi prodotti/servizi/soluzioni sono offerti sul mercato? Ad esempio, risparmio energetico, miglioramento del comfort, integrabilità con altri device e soluzioni adottati nell'edificio? Eccetera

Customer segment

- Quali sono i principali segmenti di clienti/mercato cui destinate i vostri prodotti/servizi/soluzioni per lo Smart Building?
- Quali prodotti/servizi/soluzioni offrite in ciascuno di questi mercati?

Customer relationship

- In che modo costruite una relazione a valore aggiunto con i vostri clienti/mercati target?
- Come fate comunicazione e marketing dei vostri prodotti/servizi/soluzioni per lo Smart Building in ognuno dei vostri clienti/mercati target?

Distribution channels

- Attraverso quali canali di distribuzione raggiungete i vostri segmenti di clienti/mercato target?
- Quanto è efficace ogni canale di comunicazione?
- Quanto è efficiente (dal punto di vista dei costi) ogni canale di comunicazione?

Key resources

- Quali sono le risorse più critiche per raggiungere gli obiettivi di vendita e marginalità che vi siete dati nei diversi segmenti di clienti/mercato cui vi rivolgete (ad esempio, risorse umane, tecnologiche, finanziarie, eccetera)?

Key partners

- Quali sono i principali partner con cui collaborate nello sviluppo e commercializzazione dei vostri prodotti/servizi/soluzioni per lo Smart Building?
- Che contributo fondamentale offrono i partner che coinvolgete nel vostro business model? Perché sono essenziali per veicolare la vostra value proposition nei diversi segmenti di clienti/mercato target?

Key activities

- Quali sono le principali attività relative allo sviluppo e commercializzazione dei vostri prodotti/servizi/soluzioni per lo Smart Building che svolgete internamente?

Revenue streams

- Attraverso quali canali generate revenues dalla vendita dei vostri prodotti/servizi/soluzioni per lo Smart Building (ad esempio, vendita del prodotto/servizio/soluzione, fee fissa o variabile per l'utilizzo del prodotto/servizio/soluzione, sharing dei benefici generati dall'adozione del prodotto/servizio/soluzione)?
- Quanto pesa ciascun canale (percentualmente) sulle revenues totale che generate con i vostri prodoti/servizi/soluzioni per lo Smart Building?

Cost structure

- Quali sono le principali voci di costo che sostenete per supportare il vostro modello di business?
- Come credete che il vostro business model appena descritto si evolverà nei prossimi 5 anni?

PARTE 3: Investimenti e Strategia

- Da quanto tempo siete attivi nel mercato degli Smart Building?
- Operate in questo mercato a livello italiano o anche internazionale? Se sì, quale percentuale del vostro giro d'affari nel 2018 è riconducibile ai mercati internazionali? Credete che questa percentuale crescerà, si ridurrà, o si manterrà costante nei prossimi 5 anni?
- A quanti progetti di realizzazione o ricostruzione in ottica Smart Building avete partecipato fino ad oggi?
- Quali sono i tre progetti di Smart Building più rilevanti cui avete partecipato in Italia?
- Quanti investimenti in Ricerca & Sviluppo avete dedicato a mettere a punto i vostri prodotti/servizi/soluzioni per lo Smart Building negli ultimi 5 anni?
- Vi attendete che questi investimenti cresceranno, si ridurranno, o si manterranno costanti nei prossimi 5 anni?
- Quali sono i principali vostri competitor diretti ed indiretti nel mercato dello Smart Building in Italia?
- Per entrare o crescere nel mercato dello Smart Building, avete perseguito un percorso di crescita organica o avete operato attraverso partnership e/o acquisizioni? Nel secondo caso, con che operatori avete dato vita a partnership o processi di acquisizione?
- Credete che la vostra crescita nel mercato dello Smart Building procederà nei prossimi 5 anni attraverso crescita organica o attraverso partnership e/o acquisizioni? Nel secondo caso, con che operatori pensate di dar vita a partnership o processi di acquisizione?
- Quali sono a vostro giudizio le principali barriere allo sviluppo del mercato dello Smart Building in Italia?

PARTE 4: Normativa

- Quali sono a vostro giudizio le principali norme, sistemi di incentivazione e di obbligo che stanno influenzando o promuovendo lo sviluppo del mercato dello Smart Building in Italia?
- Quale ritenete che sia e che sarà nei prossimi 5 anni il loro impatto sul mercato in Italia?
- Quali sono i paesi internazionali che hanno a vostro giudizio un sistema di norme, sistemi di incentivazione e di obbligo più virtuosi che potrebbero favorire lo sviluppo del mercato dello Smart Building in Italia?