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The Support of Digital Startups to Design Thinking Processes: the Structure of the Ecosystem and the Impact of Artificial Intelligence

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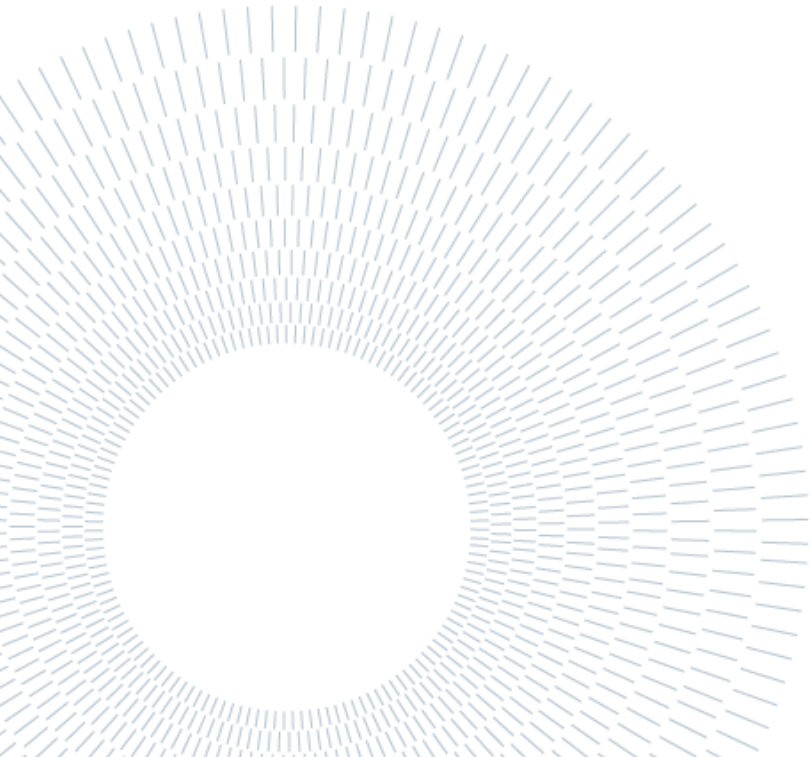


Abstract

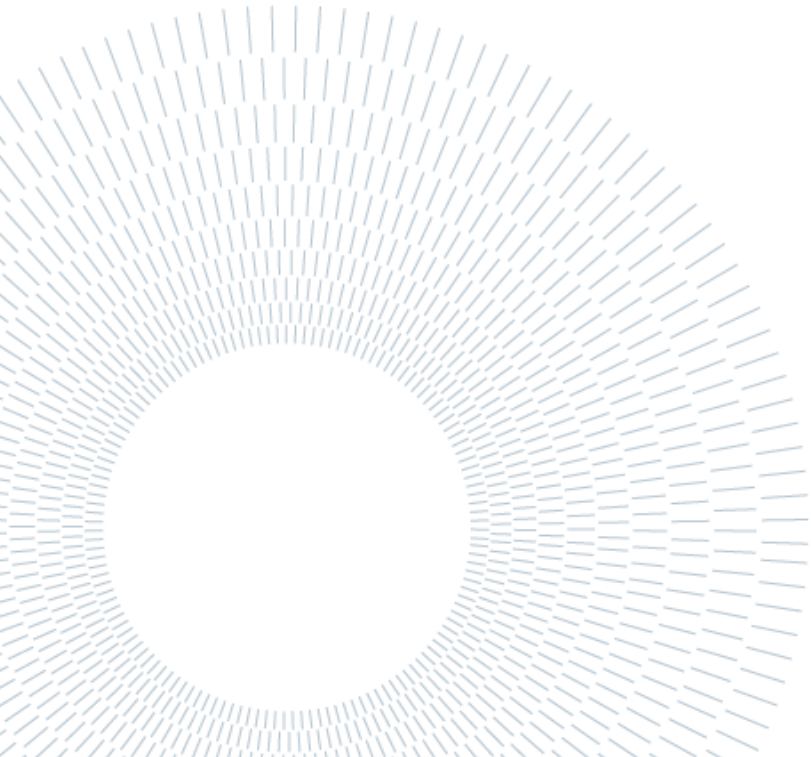
In the last years design thinking has become one of the most adopted solutions by companies to reach innovation, developing new products, services and strategies. This method helps companies in overcoming their limits and winning the competition. However, the other side of the coin is still poorly explored: how could the services of companies effectively support this process and enhance its capabilities? Particularly, this work analyses the service provided by startups, this is due to their capabilities to provide innovative solutions and, most of the times, leverage on new technologies. Indeed, the present study does not want just to explore how digital startups can enhance design thinking process, it wants to go further and truly understand how innovative technologies can sustain this subject. In particular, the focus is on Artificial Intelligence (AI), indeed, due to its capabilities of replicate humans' abilities it starts to be widely used by companies to manage their internal knowledge and to activate innovation and design processes; thus, it results suitable to affect design thinking process. This thesis aims to find an answer to two main questions: how the ecosystem of the startup which are able to effectively support design thinking practices is structured? And how the offers of this startups which are based on AI solutions impact design thinking processes? Through a database composed of 612 startups and a rich description from many viewpoints, it is provided a fully description of the ecosystem. Consequently, a multiple business case analysis has been performed identifying the main impact of AI in these terms: (i) it allows to automate activities which are poorly performed by people generating insights which allows to better empathize with the end users, (ii) it could augment people skills such as creativity and intuition supporting the abductive reasoning (iii) it allows to better understand feedback and fast testing new solutions.

Key-words: design thinking, artificial intelligence, design, innovation, startups, digital technologies.

Abstract in italiano

Negli ultimi anni, il design thinking è diventato una delle soluzioni più utilizzate dalle aziende al fine di innovarsi, sviluppare nuovi prodotti, servizi e strategie. Questo metodo è di sostegno alle aziende al fine di superare i propri limiti e affrontare con successo i propri competitor. Tuttavia, la relazione opposta è ancora poco esplorata: come possono i servizi offerti dalle imprese sostenere efficacemente il processo di design thinking, in modo da accrescerne le potenzialità? In particolare, il lavoro intende analizzare il servizio offerto dalle startup, data la loro capacità di fornire soluzioni innovative, le quali sono il più delle volte basate su nuove tecnologie. Il presente studio non vuole solamente esplorare in che modo le startup possono migliorare il processo di design thinking, bensì vuole spingersi oltre, al fine di comprendere a fondo come le tecnologie innovative possano efficacemente supportarlo. Nello specifico, il lavoro si focalizza sull'Intelligenza Artificiale (AI), poichè, considerate le sue capacità di replicare abilità umane, essa inizia ad essere ampiamente utilizzata dalle aziende al fine di gestire il livello di conoscenze interno e di attivare processi di innovazione e progettazione; per queste motivazioni si ritiene che l'AI sia la tecnologia più indicata per sostenere progetti di design thinking. Dunque, l'elaborato intende trovare risposta a due domande principali: come è strutturato l'ecosistema delle startup in grado di supportare efficacemente le pratiche di design thinking? In quale modo le offerte delle startup che basano le proprie soluzioni sull'AI influiscono sui processi di design thinking? Attraverso un database composto da 612 startup e una analisi che prende in considerazione molteplici punti di vista, viene fornita una descrizione completa dell'ecosistema. In ultimo, è stata eseguita un'analisi di diversi business case, la quale ha portato all'identificazione dell'impatto dell'AI nei seguenti termini: (i) consente l'automazione di attività che vengono solitamente svolte da persone con scarsi risultati, permettendo di generare preziosi insights che consentono di creare empatia con l'utente finale; (ii) è in grado di migliorare abilità individuali come creatività e intuizione, supportando il ragionamento abduttivo; (iii) permette una migliore comprensione dei feedback e di testare più velocemente le nuove soluzioni.

Parole chiave: Design thinking, intelligenza artificiale, design, innovazioni, startups, tecnologie digitali.



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Introduction

In recent years design thinking has become one of the major approaches adopted by organizations all over the world in order to successfully reach innovation. It allows to reshape the culture inside companies, to strengthen the relationship with the customer base by improving the engagement and, more in general, allows to have a structured and defined process which leads to a generation of new ideas and new winning solutions (Beckman & Barry, 2007; Brown, 2009; Liedtka 2015). The practice is born in North America from the collaboration between the Stanford University and IDEO a consulting company focused on the design of new solutions. The main idea upon which design thinking is built is to adopt the mental scheme of designers to the managerial realm to enhance creativity in developing not just a new product, but also innovation (Cross, 2011). The issues which design thinking aims to solve are the so called 'wicked problem' ones (Buchanan, 1992), in which both problems and solutions are unknown (Lisi, 2015), they are true dilemmas where it is necessary to put a lot of effort in the clarification of the requirements. To solve this kind of problems creativity becomes a crucial element (Buchanan, 1992), because it allows to unlock new opportunities about what 'could be' (Achillas, 2016). Indeed, according to Micheli (2019), one of the most important characteristics of a design thinking is creativity, which results in innovative solutions that are new, valuable and unexpected or surprising (Lisi, 2015). Thus, design thinking supports the abductive reasoning, the imagination of what might be challenging the existing paradigm (Martin, 2010). Moreover, this kind of practice uses always as a reference point the end user; indeed, design thinking is a human-centred approach (Brown, 2009; Martin, 2011) which means involve the end users in the creative process in order to generate a new solution which really answer to customers' needs. In this sense, empathy becomes a crucial characteristic of a design thinkers, who are able to really grasp what is valuable for the users, to generate insights and to inspire innovation (Brown, 2008). This is showed by many managers, such as Indra Nooyi, chief executive of PerpsiCo, who confirms that rather than thinking as a chief executive, she puts herself in the shoes of the customers an encourages all

employees to do the same, adopting design thinking methods to foster innovation; or, again, by companies such as Deutsche Bank which "force" employees to act as customers and use the same services and products as if they were clients in the innovation process. This is not enough to reach innovation in an effective and efficient way; in fact, design thinking adopts an iterative approach based on experimentation. This allows to test the potential solution with the end users (Beverland et al., 2015), to better define the 'wicked problem' (Beckman & Barry, 2007), to validate ideas before the launching on the market (Joshi, 2017) and to stimulate the imagination to refine the solution (Hargadon & Sutton, 1997). Considering all these elements, according to Joshi (2017), design thinking stimulates new ideas leveraging on fast prototyping, allowing people to think in a non-conventional way by taking always in mind the users' needs. In this way, design thinking has become one of the most used methods adopted by organizations to develop innovative solutions in order to satisfy customers' needs. Design thinking is also a powerful method to engage the whole organization in the innovation challenge (Aschehoug et al., 2018); indeed, it allows to shape the company's culture and create a winning mindset among members of the innovation team (Kolko, 2015). It is a philosophy which helps firms in facing the innovation challenge over the years. There are a lot of evidence regarding the increasing attention around this topic in the recent years. One proof is provided by management consulting companies which opened design thinking departments and acquired niched consultancies. Some examples are provided by EY which bought Seren a London-based service design firm, by McKinsey & Company and its acquisition of design consulting giant Lunar and Accenture which acquired INSITUM a service design and strategic research firm focused on human-centred innovation. The design thinking process is useful to incumbents which often face some limitations in reaching innovation such as the perceived incentives or the organizational routine (Chandy & Tellis, 2000). Innovation is essential to firms in orders to survive to the market competition: there are plenty of examples which show the support of design thinking in developing new solutions. For instance, Uber Eat through design thinking practices realized that to create a product that would address the unique needs of each city it needed to immerse and learn about the experience of restaurant workers, delivery partners and workers. The team's designers regularly travelled to different markets to interview users and observe their product out in the world from shadowing delivery drivers to visiting local restaurant owners. In this way, they

succeed to grasp insights, then team run experiments and built prototypes to create features, such as the "most popular items" category. Through research and iteration, the app has continued to evolve over time and transform the experience of food delivery. Another example is provided by Braun and Oral-B which were designing their new electric toothbrush: it originally wanted to create a high-tech device that could provide in-depth data on people's brushing performance. Together with designers of Future Facility, a design thinking consulting company, the team decided to pivot and change their direction in order to meet their customers' needs and developed a toothbrush that can both charge through a USB and connect with an app to easily order new bush heads. The team's research, with their users, allows them to discover that people were typically nervous about not brushing properly and that such detailed data on hygiene habit would increase their anxiety. These are key insights which shows that people were looking for ways to make brushing less stressful, the result is a product which remove barrier instead of adding new ones. These are two of many examples of success in innovation for companies which adopt design thinking processes, which allow to produce new solutions that are really in line with the end-users' needs. These practices are useful at startups level as well, in which many entrepreneurs, who are starting a new activity, use design thinking to imagine different solutions and bring them to life by discover unexplicit users' needs (Scott et al., 2016), or to validate their business models before the actual launch on the market by testing the solutions and refine them considering feedback (Mosenthal, 2016). One example is provided by Airbnb: Brian Chesky and Joe Gebbia, the two founders, define themselves as design thinkers and in many interviews they mention the design concept to foster creativity and establish their business model. At the first phase they left the Silicon Valley to meet the owners of the apartments in New York and, thanks to the direct empathy with the users, they understood that one of the main issues was related to the ability to take good or bad pictures. Despite at the beginning it seemed an unfeasible idea from a scalable viewpoint, trying to solve the problem by directly visit every homeowner, they succeed to truly understand the problem and to grasps insights and consequently find a solution which led to double the profits in the following week after the upload of the new phots.

According to Ahmed et al. (2018), design thinking, during its evolution, has been more and more involved with digital transformation and the development of new digital solutions. In this sense, design thinking process could be effective in

enhancing digital technologies such as Artificial Intelligence (AI), big data, Augmented Reality (AR) and so on. Indeed, there are many examples of use of design thinking to the development of technological solutions. For instance, the use of design thinking practices to develop big data product in which is essential identify customers' needs to discover opportunities, and, consequently, after having developed an initial version, testing and evaluate the impact (Glassberg, 2018). If, on one hand, design thinking practices could enhance the development of new digital solutions and support companies in reaching innovation; on the other hand, companies can support design thinking practices, particularly helped by technologies. Indeed, the evolution of technologies is impacting the way in which organizations approach innovation processes (Liebowitz, 2001) and design thinking (Cross, 1999). In fact, Augmented Reality (AR) and Virtual Reality (VR) have the potential to facilitate the remote collaboration and to allows to design almost everything imaginable (Ondrejka, 2007). According to the Observatory of Artificial intelligence of Politecnico di Milano (2018), technologies such as AI and big data are enhancing activities related to research and development and innovation process. Particularly, looking at AI, it is interesting understand how it can create synergies with design thinking practices and how it is possible to generate reciprocal benefits. Indeed, design thinking could help companies in adopting AI solutions, by helping to integrate a human centred way of solving problems. On the other hand, AI is potentially capable to support design thinking processes; indeed, thanks to technologies such as natural language processing, machine learning or computer vision, it is capable to perform cognitive activities similar to the ones of humans, activities such as perceiving, reasoning, learning and so on. In this way, the technology can replace activities which are poorly perform by humans, for instance by extracting new insights from data sets, and work closely to humans augmenting their capabilities, or, again, by stimulating abduction with new unrelated insights (Cautela et al., 2019; Garubio, 2021; Raisch, 2021).

Design thinking is a constantly evolving phenomenon, and the development of new technologies could potentially enhance this process and support it in many ways. After having analysed the literature related to design thinking, it was found that a lot of studies has been conducted regarding how design thinking could support innovation and digital transformation inside established companies and startups. However, it emerged a gap about the contrary: there are still few contributions on

how organizations can provide products and services to support design thinking practices. This work aims at covering this gap, focusing on the startups ecosystem. This is done considering what also emerged from the recent literature: indeed, there are few contributions which explore how innovative technologies can effectively support design thinking practices. In this sense, it is considered that many startups based their business models on disruptive technologies and, consequently, the dissertation is focused on the services and products provided by new ventures with a further analysis on the technologies adopted by them. This work is especially focused on the technology which best fitting design thinking practices thanks to its capabilities to substitute humans in some activities and effectively support them in others: AI. All the above-mentioned considerations led to the launch of this research project which wants to explore two main aspects: (i) the mapping of the ecosystem of global startups capable to support design thinking processes and (ii) how artificial intelligence impact and enhance design thinking practices. To provide a structured answer to these main points, this research proposes the creation of a database composed by startups related to the main theme which fully describe the actual ecosystem and a multiple business case analysis through eight semi structured interviews at people that works in these startups which belong to the sample and have a service based on AI.

This thesis is structured as follows: Chapter 1 regards the literature review about the theme of design thinking, its impact on digital transformation and how technologies could support this process. This led to the identification of previous gaps to the mapping of the ecosystem and then, to the creation of the startups database. Consequently, the collection of the data, a protocol in order to conduct business case interview has been established. The methodologies to correctly perform these activities are fully described in Chapter 2. The results of the analysis are described in the Chapter 3 in which it is possible first, to understand the structure of the ecosystem from a multiple point of view, and second to grasp how AI can effectively support the design thinking process through quotes directly extracted from salient point of the interviews and finally formalizing the five propositions of this research. In the end, in Chapter 4 there is the discussion about the results generated, showing all the theoretical and managerial implications and provide some insights about possible future studies.

1 Literature Review

The objective of this chapter is presenting a systematic review of the design thinking subject, from the origins to how is used nowadays. Then, the focus shift on digital innovation and, in particular, how it is addressed by digital startups. Consequently, it is illustrated the intersection between the design thinking and the digital realm, and how each of these two sides affects the other one.

The following section is structured as follows: (i) literature review on design thinking, (ii) digital innovation and (iii) the linkages between the two subjects.

1.1. Discovering design thinking

Practitioners and academics alike are more and more interested to design thinking, a subject which offers a new approach to innovation and problem solving (Micheli et al., 2019). The interest is confirmed from the fact that over the years academic journal such as the Journal of Production Innovation Management and Academy of Management Journal have published more and more articles related to design thinking (Micheli et al., 2019). According to the articles published on these renowned journals, design thinking has become an increasingly relevant concept in both innovation (Brown & Katz, 2011; Seidel & Fixson, 2013) and general management (Gruber et al., 2015).

At the beginning companies utilized design thinking practices to innovate physical products they offer. The practices were widely used by new product development teams. However, integrating design thinking into new product development reveals some challenges (Micheli et al., 2012). This is due to the very different orientation of designer in respect to the one of managers and the other group' members (Candi & Saemundsson, 2008). It is not just about a different values, behaviours and attitudes but there is a real language barrier since manager and

designer are on two different communication layers (Von Stamm, 2004) and this can lead to tensions. However, according to Micheli et al. (2012), the use of the terms is not totally different, indeed managers and designers have a shared vocabulary with additional specific words for both groups. Particularly, on one hand designers perceive materials and technology as means to reach their "ends" an iconic design; while on the other hand, managers' "ends" is the commercial one (Micheli et al., 2012).

Nowadays design thinking' goal is no more just about new product development. Many companies use these practices to solve complex problem at the strategic level (Kolko, 2015), in fact design thinking principle can be applied to reach new innovative ideas helping people to engage and organization work better as a system (Brown & Martin, 2015).

1.1.1. The concept of design

In order to grasp the meaning of design thinking it is necessary to understand the meaning of design. The goal of this paragraph is to illustrate the main concept of design and how it developed over time.

According to Krippendorff (2006), creating meaning is the true goal of design and designers' work. In fact, the term of 'design' is from Latin 'de + signare' which means making something or distinguish it by a sign (Krippendorff, 1989). Therefore, it is possible to highlight a link between design and innovation since design is about the innovation of product and service meanings (Verganti, 2011). To Verganti (2011) the meaning of a product or a service is its 'why', the profound psychological, emotional and cultural reasons people use a product. In fact, customers do not buy a product just for its functionalities, but they buy it for what it represent to them as well (Levy, 1959). Thus, it is possible to assert that the designers' work is about grasp what is truly meaningful to people. If on one hand Krippendorff thought that the core of the design process is the meaning on the other hand Simon think that the artifacts is the core while the meaning is just an attribute (Johansson-Sköldberg et al., 2013). Simon (1996) defined designed as 'the transformation of existing condition into preferred one'. This different standpoint is sustained by Owen as well, indeed he described design as a process of invention where the designer use

tools and language to create artifacts and institution (Owen, 1993). The design process aims at splitting the initial problem in different pieces, recombine together the pieces in a new way and, at the end, test the new solution to understand if the initial problem has been solved (Jones, 1970). Despite there is not a univocal definition of the term it is possible to conclude that a good design aims at satisfying both the desires and needs of the users.

1.1.2. The definition

Nowadays there is not a generally accepted definition of design thinking, in fact there is a controversy among its practitioners and advocates (Liedtka, 2015a). It is a term which has a different meaning depending on the context (Johansson-Sköldberg et al., 2013). According to Johansson- Sköldberg et al. (2013) on one hand there is the 'designerly thinking' concept, which regards the design realm, in particular skills and competence of the professional designers. On the other hand, 'design thinking' is a term used when design practice and competence are used in non-design context, from people which do not have an academic background, particularly in management, the focus of the work being on the latter. The first time the term 'design thinking' appeared in 1987, it was the title of the book authored by Peter Rowe, however the concept was not related to the business environment but to the architectural one instead. The modern usage of the term design thinking is more properly attributed to David Kelly and Tim Brown, respectively the founder and the CEO of the innovation consulting firm IDEO (Kelley & Littman, 2005; Brown, 2008). IDEO's strategy followed the path of design thinking evolution, from just focus on new product development to the design of service, strategies and social systems (Johansson-Sköldberg et al., 2013). Tim Brown asserts that design thinking can be defined as the application of designer's principle, approaches, methods and tools to problem resolution. It matches people's needs with what is technologically feasible; doing so it creates new business strategies which can exploit market opportunities (Brown, 2008 & 2009). In 2009 Thomas Lockwood, former president of the Design Management Institute, proposed a more detailed definition "a human centred innovation process that emphasizes observation, collaboration, fast learning, visualization of ideas, rapid concept prototyping and concurrent business analysis".

According to Buchanan's (1992), the starting point of the design thinking process is the resolution of 'wicked problems'. Rittel in 1972 defined wicked problems as a "class of social system problems which are ill-formulated, where the information is confusing, where there are many clients and decision makers with conflicting values, and where the ramifications in the whole system are thoroughly confusing". The formulation of the wicked problem is the problem, indeed the information needed to understand the problem depends upon one's idea for solving it (Rittel & Webber, 1973). In these dilemmas both problem and solutions are unknown at the beginning (Lisi, 2015). Therefore, it is necessary that considerable effort is spent to clarify the requirement, indeed a large part of the design thinking process consist in the problem definition phase (Rowe, 1987). To reach the goal of solving the 'wicked problems' creativity becomes a crucial element (Buchanan, 1992). In this way, design thinking enhance the creativity process as well, in fact it provides step-by-step guidelines useful to operationalize the desire for creativity (Zidulka & Kajzer Mitchell, 2018), thus, thinking like a designer becomes a crucial point. In fact, among all the characteristics of a design thinker one of the most important one is the integrative thinking (Brown, 2008): the ability to not only rely on analytical processes but also to notice all the relevant aspects and create a new solution which dramatically improve the existing one. In other words, the integrative thinking combines the abductive logic, so the ability to generate new ideas with the deductive, inductive logic, so the analysis and evaluation of how these ideas apply (R. Martin & Dunne, 2006).

Find a single definition of design thinking is not possible and is not useful as well, since it can take a different form considering different context, thus, try to find a single definition would be to fail in an essential trap (Johansson-Sköldberg et al., 2013). This is also sustained by Carlgren et al. (2016), she investigated how companies manage design thinking project internally. The results showed a high variability not only between different companies but also among different team in the same firm. Indeed, design thinking rather than a well-defined process is a mindset, it exploits the brilliance of the people of the organization in order to unleashing creativity and innovation (Tripp, 2013). According to Carlgren et al. (2016) "design thinking can be seen as a process, or as methods, a toolbox, a mental approach, a culture or a mix thereof".

1.1.3. Principal attributes

This section aims at exploring the main characteristics of design thinking practices. The 10 key concepts related to design thinking emerged from a study conducted by Micheli et al. in 2019. The work consisted in interviewing a group of designers and discover what they consider relevant element regarding design thinking. The 10 key concepts emerged are as follow:

1. *Creativity and innovation*: creativity is intended as the generation of useful idea by individual or small group of people which work together (Amabile, 1988). It results in product which are new, useful or valuable and unexpected or surprising (Lisi, 2015). While innovation is defined as the implementation of new creative ideas inside a company (Amabile, 1988). These two aspects are almost always reported as motivation for apply design thinking practices. For instance, the former CEO of P&G Lafley asserts that "design thinking is a way of thinking that fosters creativity and innovation in products and service, as well as new approaches to business and organization" (Lafley et al., 2013).
2. *User-centredness and involvement*: one of the fundamental pillar of design thinking principle is the user- or human- centeredness (Brown, 2009; Martin, 2011). The meaning of this concept is that the end user should participate during the creative process. The user should have influence and should take initiatives in the role in which they provide expertise and being involved in the activities in the early design phases (Sanders and Stappers, 2008). Empathy became essential to obtain and effective involvement of the user, since it is "the core value of human-centeredness" (Carlgren, Rauth, et al., 2016). Empathy is one of the main attributes of the design-thinker, it means imagine the world from multiple perspectives and imagine solution that meet explicit and latent needs (Brown, 2008).
3. *Problem solving*: design thinking is widely considered an innovative way of solving problems, in particular, as mentioned above, 'wicked problem' dilemmas (Buchanan, 1992). Thus, design thinking practices is proposed as an alternative to the traditional linear problem-solving approach (Luchs, 2016; Martin 2010).
4. *Iteration and experimentation*: design thinking is an iterative approach which is based on trial-and-error learning, the iteration aims at test a range of

possible solution with the potential customers and other stakeholders (Beverland et al., 2015). Iteration becomes an essential activity in the resolution of 'wicked problems', this because it is utilized to better define the problem (Beckman & Barry, 2007) and to experimental solution creation (Rylander, 2009). During the iterative process often are used sketches, mock-ups and prototypes in order to make the idea tangible (McCullagh, 2013). Especially prototypes fulfil a very important role, since they allow stakeholders to really grasp the idea with its strengths and weaknesses and subsequently identify insights that can guide the creation of the next prototype (Brown, 2008). Prototyping is not about validating an idea but about stimulate the imagination (Hargadon & Sutton, 1997), thus it is important the speed with which it can be built and used (Meyer & Marion, 2010). Rapid prototyping is a best practice because a company can be more confident about the success of the project (Brown & Martin, 2015)

5. *Interdisciplinary collaboration*: the integration of different perspectives from people both inside and outside the company is a central point of design thinking practices (Carlgren et al., 2016). Establish multidisciplinary teams can help to address the complexity of the project and guarantee that technical, business and human dimensions are all represented (Glen et al., 2014). In fact, the resolution of wicked problems takes form by bringing people together from different disciplines (Beverland, Micheli, & Farrelly, 2016). Thus, according to Brown (2008) collaboration is one of the essential characteristics of a design thinker, the myth of the lone creative genius is replaced by interdisciplinary collaborators, because "you get to a place that you just can't get with one mind" (Camacho & Kelly, 2016).
6. *Ability to visualize*: according to several authors, the heart of design for innovation consist in moving from an abstract thinking to visualizing ideas and subsequently thinking on top of the latter (Boni et al., 2009). The design thinker's ability of visualize defines their practice and approach to problem solving; thus, it forms an important part of design thinking (Deserti & Rizzo, 2014; Kimbell, 2011). In fact, the early visualization of concept and ideas plays a crucial role to guide an emerging inquiry (Cooper, Junginger, & Lockwood, 2009). The ability to visualize is often associated with the creation of artifacts, sketches or prototypes (Micheli et al., 2019). Some researchers believe that one of the most important characteristics of design thinkers is the ability to

observe, visualize, use artifacts to explore, define and communicate (Drews, 2009; Glen et al., 2014; Kolko, 2015; Razzouk and Shute, 2012). In their opinion design thinking should be intimately related to design practices (Deserti & Rizzo, 2014) and not just root in the practices and processes adopted by designers (Beverland et al., 2015).

7. *Gestalt view*: one of the main characteristics of design thinking practices is the use of an integrative approach which allows to deep understand the context of the problem and to grasp relevant insights (Gruber et al., 2015; Nedergaard & Gyrd-Jones, 2013). In the field of traditional design, the term gestalt means that the perception of the whole is just the sum of the perception of its parts s (Bloch, 1995; Noble & Kumar, 2010), rather is a solution which transcend solution provided by individual components. In this sense, design thinking relies on the general "understanding of the problem, including a customer's needs (explicit and tacit), the end-user's environment, social factors, market adjacencies, and emerging trends" (Holloway, 2009). The consideration of multiple stakeholders, the context and the contingencies enable design thinkers to re-formulate the problem in a holistic way (Drews, 2009), producing "an elegant integrated whole, or gestalt" (Vogel, 2009).
8. *Abductive reasoning*: it is not the analysis of what is, rather it is the imagination of what might be (Roger Martin, 2010). It can be consider as an alternative approach to deductive and inductive reasoning (Micheli et al., 2019) and, unlike the other two logics, it lead to new knowledge and insights (Kolko, 2010). Therefore, abductive reasoning promotes an "attitude towards workable solution [that] is 'assertion-based rather than evidence-based'" (Michlewski, 2008). Thus, a design thinker can approach the solution of a problem in two different ways. On one hand using existing frame and on the other hand challenging existing practices and assumptions (Micheli et al., 2019). The latter represents the linking point between innovation and traditional design-based practices (Dorst, 2011).
9. *Tolerance of ambiguity and failure*: design thinking is about the resolution of wicked problems, thus, in this case the ambiguity is inherent. Design thinkers should be able to embrace this ambiguity and try to reduce it by iterative trial-and error cycles which aim to fail to collect useful feedback (Adams, Daly, Mann, & Dall'Alba, 2011). Fail becomes a value-added activity because

allows fast learning; indeed, failure can be considered as an opportunity to improve the product/service and create a better solution (Luchs, Swan, & Creusen, 2016). The earlier the organization learn the better, in this sense rapid prototyping, which can be considered as inexpensive failures, can help to better understand how to pursue the right solution (Glen et al., 2014).

10. *Blending analysis and intuition*: design thinking is not to consider as against analytical think, rather it must merge and combine analytical and intuitive thinking (Martin, 2010). According to Martin (2009) the distinctive feature of design thinking is the ability to dynamically balance opposite elements: on one hand rationality and analysis and on the other hand intuition and synthesis.

1.1.4. The process and its metaphases

The following part aims to provide to the reader a clear view about design thinking processes. Despite it is not present a unique structure on which all the academics agree, generally it is possible to confirm the presence of at least three macro-phases (Liedtka, 2015). There is not a common definition of these macro-phases, however, it is possible to assert that each design thinking process involves acquisition of data about users' needs, generation of new ideas and testing of the latter. In 2008 Brown, the CEO of IDEO, define the phases as 'inspiration', 'ideation' and 'implementation'. According to the definition of IDEO, the steps are about 'discovery and interpretation', 'ideation' and 'experimentation and evolution'. While the design school of Stanford labels them as 'emphasize and define', 'ideation' and 'prototype and test'. One of the main characteristics of design thinking practices is the user-centredness, in this sense the first phase, called 'need finding' (Seidel & Fixson, 2013), is focused on determine the requirements and framing the problem. It is about fully grasp and understand the user's needs, and, in order to do that, observation, empathy and immersion in the context of the users becomes fundamental (Brown, 2009). The next phase is the 'ideation' one, which aims to find new winning solutions. In this step collaboration became fundamental, the work is done in group and the team is composed by people with different expertise. Here, in order to explore many possible solutions, design thinkers use

divergent thinking and convergent thinking (Cross, 2006). The first is about offer different, unique or variant ideas adherent to one theme while convergent thinking is the ability to find the "correct" solution to the given problem. In this phase is important reach the 'a-ha moment', in this instant the path to follow becomes clear in the mind of the design thinker (Lisi, 2015). This point is where synthesis and divergent thinking, analysis and convergent thinking meet with the problem and a potential resolution emerges as an outcome. The last part of the process is about porotype and test: here the idea becomes physical and tangible in a preliminary model (Seidel & Fixson, 2013). This aims at enabling learning, evaluation and testing from the feedback.

From a different standpoint, is important to highlight the model about design process by Owen (1993), which views design as a process of knowledge development. Owen suggests the presence of both analytic and synthetic elements in the process and that it operates in both the theoretical and practical realms. The analytical phase of design is about finding and discovery, while the synthetic phase of design is focused on invention and making. Regarding the theoretical and practical realms, there is a continuous dependence. Indeed, the movement between the two groups happens as the teams grasp insights from what they learned by experience, then convert them into theories and then translate those theories into the practice world (Beckman & Barry, 2007).

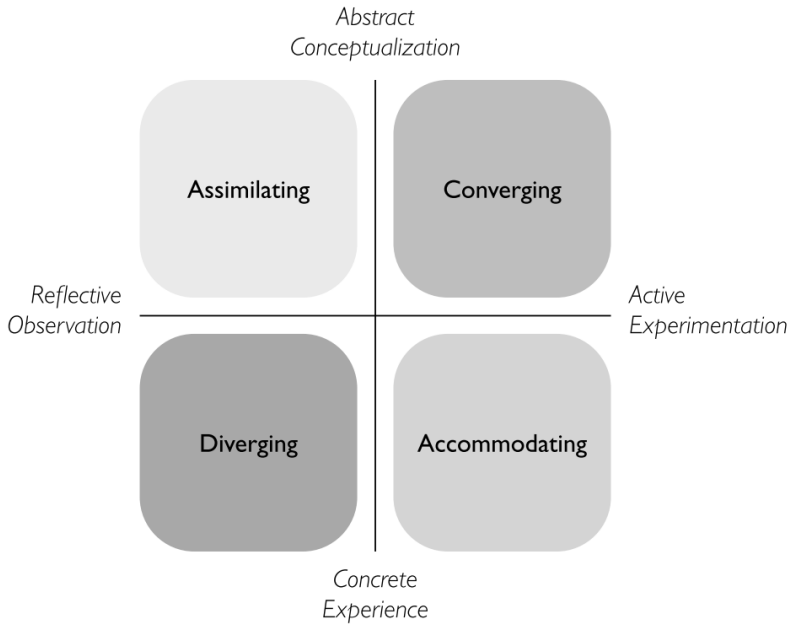

Figure 1: The four learning styles (Beckman a& Barry, 2007)

The matrix is the result of the experiential learning theory; indeed, this model juxtaposes two approaches to grasping experience, namely the concrete experience and the abstract conceptualization, and two approaches to transforming experience, which are the reflective observation and the active experimentation. The dichotomies define four different learning styles: diverging, assimilating, converging and accommodating. Individuals can belong to different groups according to their natural characteristics. People who prefer idea generation activities prefers a diverging style, while the ones which prefer technical tasks over social activities belongs to the converging style. Assimilating style includes individuals which are skilled to manage a lot of data and order them in a logical way, while individuals with the accommodating style prefer hands-on experience and action-oriented learning. The individual preference for a certain learning style derived from the personality, educational specialization, professional career. It is important to highlight that the learning style is not a fixed trait for a certain person, rather it can be adapted; in fact, "people create themselves through the choice of actual occasions they live through." (Kolb, 1984). The notion of adaptability is critical to the implementation of the design process, since during the process could be necessary to transform the style according to the situation. For companies which

want effectively to innovate becomes important create environments and situations that cause their employees to adapt and team up diverse colleague to assure the complete presence of the four-learning style.

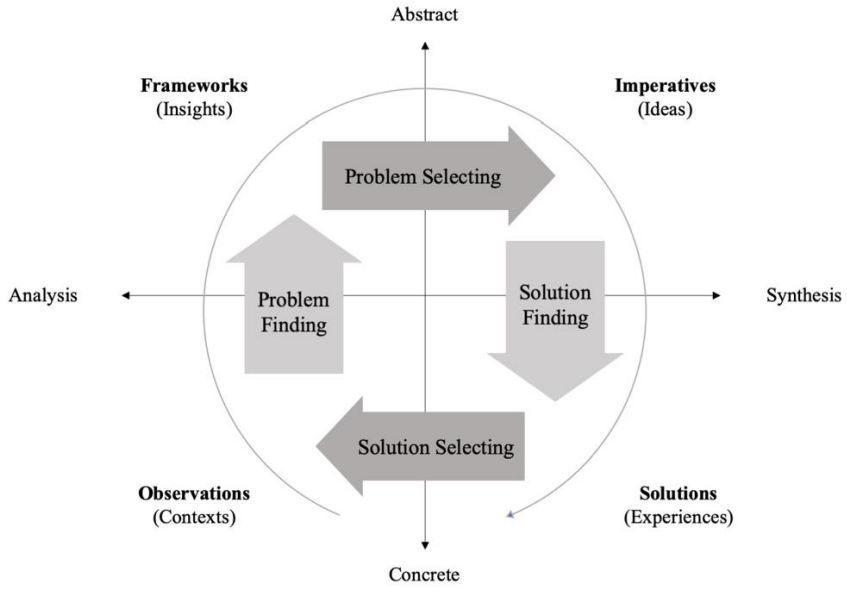

Figure 2: The innovation process as problem and solution finding and selecting

(Backman & Barry, 2007)

The innovation process developed by Beckman and Berry (2007), as the framework of Owen, moves the participant between the concrete and abstract world. Moreover, it makes use on analysis and synthesis to generate new products, services, business model and other designs. The iterative process is composed from four main phases: observations, frameworks, imperatives and solutions.

Observations is about the deep understanding on the context of engagement and use of a solution: in this phase the concrete analytical work is done. This phase is one of the main differences with traditional thinking; in fact, in traditional thinking one of the common errors is to jump in the ideating phase. As soon as our brain recognize a piece of information as part of a pattern, it subconsciously jumps ahead to a possible conclusion; this lead to fail at considering a broader range of solution (May, 2012). Design thinking is focused on understanding of customers and user

needs, so to define the problem before jumping into the resolution. Through observational or ethnographic research, the focus is not just the understanding of fundamental use and the usability needs, rather it is important grasp the meaning-based needs (Mariampolski, 2005). The latter are the core of good observational research, in fact, understand the 'why', so the meaning-based needs, leads to radical innovation (Diller, Shedroff & Rhea; 2006).

The second step is frameworks, indeed, once the data are generated from observation in the concreate realm, the model moves to the abstract one. The goal is to make sense of the data collected, framing and reframing them to extract nuggets, identify some patterns. Obviously this step is about processing a large amount of data, and this represent the main challenge, however, the team must always taking in mind what is missing for the users (Beckman & Barry, 2007). The outcome of this step is to come up with a new story to tell how the resolution of the problem could be done or to see the problem with a new perspective. Thus, this step allows the team to get the instruments with which they can reach a new solution.

Third, the innovation process moves to synthesizing a set of imperatives which can be also describe as the new value propositions that the new idea must met (Treacy & Wiersema, 1995). In this phase the innovation team decides which will be the new value proposition on the base of the insight emerged during the framing activities (Beckman & Barry, 2007). According to Beckman and Barry (2007) the formulation of the imperatives often is the first major point of convergence for the team. Indeed, in this phase, after a divergent and exploratory stage, unviable options are discarded and a very high-level specification for the design is provided.

The last stage is where the generation of the solution is done, there is the selection of the idea which best meet the imperatives. The solution must be tested with potential customers to soliciting feedback from them. The use of prototypes is necessary to fully stimulate the potential users and so obtain useful feedback. In this sense, it is important define a priori what the team wants to learn from the prototyping process.

The process is highly iterative and not thought to be linear. The innovation team has to test multiple solutions, mix the feedback with early ideas and create new solutions, and test again until the winning solution is found.

Overall, according to Liedtka and Ogilvie (2011) the design thinking process aims to answer to four main questions:

- *What is?* – understand and develop the problem;
- *What if?* – considering new possible ideas;
- *What wows?* – test the idea generated;
- *What works?* – exploring the feasibility.

The Observatory of design thinking of Politecnico di Milano defined seven metaphases, in attempt to provide a common ground and link the different perspective above mentioned. The design thinking metaphases are structured as follow:

1. *Sensing and emphasizing*: the goal is to deeply understand the user needs and the contest of the analysis. This is possible through empathy with the customers;
2. *Interpreting and framing*: design thinkers set and frame the problem by organizing all the insights gained during the previous step;
3. *Team building and task management*: creation of heterogeneous and cross-functional teams to have different point of view and opinions and guarantee open-mindedness;
4. *Ideating and conceiving*: try to solve the problem with creativity and the following generation of new ideas;
5. *Collaborating and co-designing*: the new concept is generated in detail by taking in consideration individual and team work contribution;
6. *Prototyping and learning*: a rough version of the concept is physically realized to allow an interaction with the users. The goal is to obtain feedback and recommendation from potential customers;
7. *Launching and measuring*: beta solutions are provided to market or user labs where first reaction and KPIS are monitored;

1.1.5. Tools and methods

In this section is present an overall description of the main tools and methods inherent to design thinking practices.

During the first step regarding the observation to frame the problem, according to Beckman and Barry (2007), ethnographic methods such as observation, interviewing and use of informant diaries are often used. Since one of the main pillars of design thinking practices is the user-centricity, the use of tools such as personas and customer journey maps are typically used. This in order to better understand the behaviours of users in their habitat. Welsh and Dehler in 2012 described the personas tool as the representation of the 'typical' users, and they assert that this symbol is often used by innovation teams. Regarding the customer journey map Dalton and Kahute (2017), state that is a useful instrument to fully understand the experience of the customer, not just what he/she faces but also how the user reacts according to different situations. These methods are really useful to create a baseline for discussion with stakeholders of a design thinking process and helps to maintain the user centred approach. After the observation phase it is important frame and set the problem, this step might be challenging; thus, frameworks such as "how might we…" or "5 Why" are often used. Then, during the divergent phase, tools like mind maps or brainstorming sessions become useful to generate potential ideas. On one hand, the innovation team can easily collaborate through the creation of mind maps. The maps aims at creating a common mind among the group by connecting insight emerged during the observation phase (Liedtka, 2015). On the other hand, brainstorming sessions are fundamental because design thinking is not about individual ideation: in fact, the search for new solutions rely on collaboration (Seidel & Fixson, 2013). According to Liedtka (2015), another interesting method often used during concept development is the assumption surfacing. This method aims at identifying all the assumptions around value creation, execution, scalability and defensibility to define if investigate on a possible idea or not. Regarding the exploration and testing of the potential solution to obtain feedback from potential users many instruments have been identified. The concept sharing with team or with users is allowed with tools such as field experiments, prototypes and visualisation techniques like drawing and pictures (Dalsgaard, 2014). Field experiments are done to bring solution to potential customers, this activity aims to stimulate feedback and validate the assumptions elaborated in the

previous step. Visualization techniques can be done with very simple objects like paper, cardboard or Lego. Regarding prototyping there are many techniques such as storyboarding, user scenarios, experience journey, metaphors and business concept illustrations. According to Brown (2008) the prototype has not to be complex or expensive; in fact, the more finished is the worst. It is important to remember which is the goal of the artifact, that is not about to be perfect, rather it aims at obtaining the attention of the end-users and their precious feedback. It can be consider also useful for the innovation team since having something physical in the hands and this allows, together with the feedback, a more vivid representation in the future (Liedtka, 2015). The tools and methods used in design thinking practices are also used in order to reduce the cognitive bias (Liedtka, 2015) and this leads to a more effective solution. For instance, bias such projection (the projection of the decision maker's past into the imagination of the new future) (Gilbert, Gill, and Wilson; 2002) can be mitigate through the collection of customers' data; doing so the design thinker adopts the users' perspective. This bias is mitigated by the collaboration and team working as well. Another possible bias that could be mitigate is the say/do gap one: it refers to the fact that many customers are not able to describe their behaviour in a reliable way (Fellmann, 1999). The use of qualitative research methodologies, that questioning users about behaviours rather than preferences, allows the teams to assess the needs in a more accurate way (Mariampolski, 1999). Tools such as journey mapping and job-to-be-done analysis help users to describe the experience and their thoughts, in this sense this methods help to identify needs that customers cannot easily articulate alone (Liedtka, 2015). Overall, it is possible to assert that design thinking uses tools and methods that are widely diffused in other practices. However, the innovation in design thinking process is not in the use of new innovative tools; rather is about the use of already existing tolls in a smart and coordinated way which aims to come up with a winning solution. The combination of this methods make design thinking practices an end-to-end system to solve problem and reach innovation (Liedtka, 2015b).

1.1.6. The four approaches

This section aims to describe the four different approaches with which design thinking is used in companies. Over the years many practitioners have applied design thinking in a different wat and this, on one hand leads, to an evolution of the subject and, on the other hand, to and increase of complexity and lack of clarity (Carlgren, 2013). The four approaches which emerged from the present literature are: creative problem solving, sprint execution, creative confidence and innovation of meaning. The presence of different approaches is also due to the nature of design thinking, in fact, it is possible to apply it according to the context and take different forms. The description of the different approaches and the differences among them are as follow:

- *Creative problem-solving approach*: here the focus is on one of the main pillars of design thinking, the capability of solving users' problem. The idea is that the company must understand which are the needs of its customer base and it must develop viable idea that might fill the discovered gap. This approach does not aim to find the perfect resolution, rather it is more focused on the divergent phase, in order to discover as many opportunities as possible. The end-users are the reference point for every step of the innovation process. In the creative problem-solving approach, the perspective is outside-in, this means that the starting points are the users' needs identified by market research an customers' observation (Beckman & Barry, 2007). Once the problem is properly framed there are the divergent and convergent phases in sequence. This leads to the creation of a prototype based on the solution selected, the creation of a prototype aims to physically interact with customers to obtain feedback. The members of the innovation team must leverage on the conscious and unconscious part of their brain (Bicen & Johnson, 2015). They must be able to generate multiple ideas, passing between divergent to convergent moments. A common representation of this process is the Double Diamond framework. The first diamond is about the problem, during the divergent phase there is its discovery and then in the convergent phase its definition. While the second diamond is about the developing of a solution during the divergent phase and the delivering of the outcome in the convergent phase.

- *Sprint execution approach*: this approach can be considered as the natural evolution of the first one. According to Ries (2011) the focus is on delivering a ready-to-go product on the market which can satisfy the needs of the users. The approach is practical (Aschehoug et al., 2018) and aims to a fast development of the solution which must be realistic and working. The sprint execution does not start from the information about the customers, rather it is an inside-out approach (Ries, 2011). This means that is the innovation does not start from observing the customers and understanding what they want, rather is about the innovation teams that make a discovery or invent something new. Despite not being the starting point the role of the end-users is still relevant. Indeed, most of the time, after the conceptualization of the solution, the team creates a Minimum Viable Product (MVP), which approximates the solution which aims to collect feedback from customers (Ries, 2011). Although there are some similarities between sprint execution approach and creative problem-solving approach, the main difference is in the change of the perspective. In fact, this approach is focused on the converging phase and the creation of the solution; rather, the first one is focused on the diverging phase and the definition of the problem. During a sprint execution there are four main steps to be followed: (i) decide the road to take in the new product development, (ii) create an MVP and test it on the market, (iii) measure the result obtained from the launch and (iv) learn from the results and improve your solution.
- *Creative confidence approach*: according to Aschehoug et. al. (2018), this approach regards the effect of design thinking practices in engaging people to reach innovation. The application of design thinking in an organization can shape the culture and create the right mindset among team members (Kolko, 2015). This approach has as an objective the increasing of employees' confidence when facing innovation challenges. During the design thinking process having all the team members involved and motivated is crucial, because the contribution of each one is essential (Yu et al., 2017). There are four main pillars upon which it is possible to build an effective collaboration, they are (i) engagement, (ii) co-design, (iii) involvement and (iv) co-development.
- *Innovation of meaning*: this approach aims to completely reshape the current meaning of product/service, it aims at find a new 'why', so the profound

psychological, emotional and cultural reasons people use a product (Verganti, 2011). Even this approach is inside-out, this means that the starting point of the innovation process is inside the organization and it does not come from customers. Design thinking practices allow to challenge the status quo, which is the main point of the innovation on meaning (Verganti, 2009). The objective is about grasping what is truly meaningful to people, what the product/service represents to them and understand how to create something that the user fall in love with. The launching of the innovative solution starts from the introspection of the individual. Overall, the main point during the innovation of meaning process are (i) envisioning a new direction, (ii) criticizing the direction taken by discuss with team members and external experts, (iii) probing and (iv) discuss with end-users to obtain feedback regarding the new meaning.

1.1.7. The role in radical innovation

In the previous paragraph different approaches have been presented, and different way to create innovation. Considering the contrast in the scientific literature regarding the role of design thinking in radical innovation, this section aims to illustrate the different point of view of academics and practitioners. According to Wind and Mahajan (1997) radical innovation allows company to incorporate a substantially different core technology, to follow emerging trends and to create discontinuity in the market. The radical innovation completely changes the competitive scenario of the market by provides substantially higher customer benefits relative to previous products in the industry (Chandy & Tells, 1998).

Academics such as Verganti (2011) assert that with a market pull approach is not possible to reach a radical innovation. So, this 'disruptive' innovation cannot come from the observation of the users and their behaviours. The starting point cannot be the end-users' needs since it would lead just to an improvement of the current solution. This situation is often experienced by large companies which are uncapable to innovate their offer because they are focused on satisfy the customer needs. Indeed, the incumbents face three main problems when they try to implement radical innovation: perceived incentives, organizational filters and

organizational routine (Chandy & Tellis, 2000). In particular, the organizational filers, which are the cognitive structure which define which tasks are important in an organization, enable the firm to focus on its current challenges. These filters hep them process consumer request and complaints and ensure that the current products meet consumer expectations as effectively as possible. This, inevitably, makes them lose the big picture (Christensen, 1997). Another limitation is due to the organizational routines, which are the procedure developed by incumbents over the years. These routines are ineffective at developing radical innovation (Chandy & Tellis, 2000). Adoption of radical innovation would obsolete many of these routines and require a development of new ones, and this is difficult, costly and risky (Hannan and Freeman 1977; Nelson and Winter 1982). The incumbents also perceive the risk of cannibalization of their existing product, in this sense, they do not perceive the incentives in introducing radical innovation. Since the radically new products/service as the potential to make the existing product obsolete, incumbents have a lower marginal incentive than non-incumbents to commercialize radical innovation in the short run (Ali 1994; Reinganum 1983). Considering all these reasons it is possible to assert that many radical innovations come from non-incumbent companies, in particular startups (Acs & Audretsch, 1989; Cohan, 2012). Startups which succeed are the ones able to work in turbulent market in terms of demand, technology and competition. Their main advantage over the incumbent is that there are not 'trapped' by existing offer, routine and they have all the incentive to develop a breakthrough solution. Moreover, the fact that they are strictly constrained by resources represent a counteractive advantage, indeed, this helps these organizations to focus on what they have and how to use it to do the best (Bicen & Johnson, 2015). In this sense, Bicen and Johnson (2015) arguing that design thinking practices could have a role in turbulent and resource-limited scenarios. They assert the adoption by organization on design thinking allow to apply combination of available resources in fast prototyping to better understand the problem and discover opportunities in an experimental way. Design thinking is not just about observe the users and understand their needs. Instead, thanks to the abductive reasoning, which is a fundamental element of the subject, design thinkers can reach 'what could be'. This is crucial in discovering radical innovation which is about think beyond what is observable and try to imagine what it could possibly be (Bicen & Johnson, 2015). The abductive reasoning allows organizations to ideate something new, then it is necessary test it with a deductive reasoning; design

thinking process is based on this way of working. In this sense, design thinking mixes the inside-out approach with the outside-in one, the starting point is the deep understanding of the users' needs, but then it is not about improve the existing solution, instead is about discover a radical one.

1.2. Digital innovation

In the last years a digital revolution progressing rapidly thanks to the fast development of technologies such as big data, internet of things (IoT), robotics and artificial intelligence (AI) (Ueda et al., 2018). The role of IT is become central in almost every market, thanks to its capacity to renew business models and reach a competitive advantage. These digital solutions can give amazing advantages; however, it is necessary implement it in the right way and understand how apply it according to the context. Indeed, many times companies rely on third party to gain strategic advice about the digital strategy to pursue (Adomavicius et al., 2008). In this sense, companies are trying to reach a digital innovation, so the innovation of their business model with the implementation of new technologies. According to Barret, Davidson et al. (2015) is possible to define digital innovation as a new way to combine digital and physical components by combining heterogeneous data to provide new products or service. Another possible definition is asserted by Woodard et al. (2013), for them digital innovation is about the transformation of products ore the creation of new ones with the use of digital artifacts, which are applications or media contents which offer a new functionality or value to the users. They can be hardware or software components, placed on a device or a small part of a digital platform, for instance a mobile app. According to Gustavsson and Ljunberg (2018) it is possible to list some characteristics which belong to digital artifacts:

- *Programmable*: it is possible to modifying existing artefacts as well as create new ones by exploiting knowledge in programming;
- *Editable*: it is a built-in property which gives the possibility to create and update contents, for instance in blogs or vlogs;
- *Interaction*: the end-user can interact with the function that the digital artefact presents;

- *Combined*: the digital artifacts can be the result of a combination of multiple sources and software. For instance, the use of APIs, a software intermediary that allows to application to talk each other, can lead to the creation of new experience;
- *Connected*: is the possibly to connect unconnected artefacts, and so to allow the transparent movement of data. In this way the artefacts become interoperable.

Form these characteristics the fundamental proprieties emerged: re-programmability, data homogenization, and the self-referential nature of digital technology (Yoo et al. 2010; Yoo et al. 2012; Kallinikos et al. 2013). Innovators and entrepreneurs, by leveraging these properties, discover unpresented opportunities; these because the peculiar properties reveal two very important characteristics of innovation which are convergence and generativity (Gustavsson & Ljungberg, 2018). Generativity is about the possibility to fuse together in the same domain infrastructure, service and appliances that were previously divided (Tilson et al., 2010). On the other hand, there is generativity which the fact that innovations lead to new innovations; in this sense digital technologies spur innovation, indeed, they are unfinished and malleable, and this stimulate experimentation and the realization of new solutions (Gustavsson & Ljungberg, 2018). By considering generativity the entrepreneur become crucial to foster innovation in the digital realm. In fact, he/she, by following the opportunities discovered by leveraging the technologies' properties, not only create or discover innovation (Alvarez & Barney, 2007), but also enable it (Gustavsson & Ljungberg, 2018). This because, considering the nature of technologies which is intentionally unfinished (Kallinikos et. al, 2013), the digital creations of the entrepreneur open up for other to use or build upon; in other words, they enable opportunities that can be used as building blocks for innovation by other entrepreneurs (Gustavsson & Ljungberg, 2018). The entrepreneur becomes a crucial element for innovation to spread, this is asserted by Schumpeter which put forward a view where entrepreneurship, performed either by individual or firms, in the driving force of innovation.

Digital transformation allows the creation of new business models which have different characteristics respect to traditionalises, mainly in terms of production and diffusion speed (Parker et al., 2016). The new business models are enabled by

technologies such as AI, 3D printing, mobile, IoT, robotics, social media and other digital platform (Cavallo et al., 2019). A successful digital entrepreneur is the one capable to consider three main factors and combine them in a strategical way. According to Davidson & Vaast (2010) the factors are:

- *Business entrepreneurship*: the economic realm, the capability to generate financial profit from the commercialization of an innovation. For instance, Amazon.com which was the first companies to digitalize the commercial process of retail and establish a new business model;
- *Knowledge entrepreneurship*: Skrzeszewski (2006) defines it as the capability to create and use intellectual asset for the development of new product or service that will lead to wealth creation. Consultants, journalists and academics are an example of potential knowledge entrepreneurs (Wang & Ramiller, 2009), they differentiate themselves through the use of intellectual capital (Senges, Brown, & Rheingold; 2000);
- *Institutional entrepreneurship*: defined as the activities of actors who leverage resources to create new institutions or transforming new ones (Maguire, Hardy & Lawrence, 2006). Corporations which help to establish new technical standards that have implication also for other companies in the industries.

1.2.1. Digital startups

The development of technologies over the years offers many opportunities which can be exploit by entrepreneurs. Which are the ones who identify and exploit opportunities in order to create value and gain a profits (Gustavsson & Ljungberg, 2018). Once the opportunities is identified, a startup can be created in order to exploit the opportunity (Ghezzi, 2018). In this way, it is useful provide a definition of a startup, which is, according to S. Blank (2007), the temporary situation in which a company is trying to replicate its business model reaching a scalable solution. So, they are new organizations which aims to conquer the market by launching innovation that are based on new ideas (Kuester et al., 2018). In particular, regarding the digital realm, on one side there are digital companies which usually involve offline service provided online and for which the value proposition does not first

emerge from internet (e.g. online travel booking) (Kuester et al., 2018). While, on the other side, there are digital startups which offer new and unique value proposition, based on new technologies, which aim to innovate the market (e.g. Dropbox, Whatsapp or Twitter) (Dotzel, Shankar, & Berry, 2013). The 90% of the digital startups fails in the first years of life (Marmer et al., 2011), this is because they are characterized by high-risk (Cavallo et al., 2019), especially in regarding the demand side, in particular uncertainty about customers' needs and expectations. Thus, it becomes crucial for digital ventures to validate as soon as possible the assumptions which are the pillars of their business model, in order to understand if they have the right offer and, if it so, scale up (Ghezzi, 2018) or adjusting their hypothesis according to the result of the validation. This in order to mitigate uncertainty and so reduce the risk, startups can use signals (Kuester et al., 2018). Signals are a way of companies to communicate to their potential customer base; the objective is to reduce information asymmetry, and, consequently, improve the relationship with the end-users. They can be for instance prices or warranties, and they are useful to make explicit information which are not observable. By doing so the level of comprehension of the offer rises and customers are more willing to make transactions (Kuester et al., 2018). The creation of a strong relationship between the startups and its potential customer base can be a crucial element for the companies to increase volume, to scale up and to win the competition. According to Foss and Saebi (2018) innovation can moves along two different directions: the first is about new product development (NPD), so adapting the offer according to the needs of the market; while the second one, is about business model innovation (BMI), which is about the change in a business model or in the architecture which link the key elements of a firm. The first step for a digital startup which aims at introducing an innovation in the market is to obtain customer validation. This is possible thanks to the figure of 'early evangelist', which are people who have experienced the problem under analysis (Blank, 2007). Evangelists and the startups work together in iterative cycles to obtain feedback and improve the solution. This step ends with the identification of a market in which the organization can operate by selling its product/service (Ghezzi, 2018). Then the startup must consider how the diffusion of an innovation works; according to Rogers (1995) everyone's innovation decision is largely influenced by personal characteristics and the propension to embrace innovation. He asserts that there are five different categories, each one defined by the degree to which an individual Is relatively earlier in adopting new ideas than

other members of the system. The groups are: (i) innovators, (ii) early adopters, (iii) early majority, (iv) late majority and (v) laggards. The interaction among these groups triggers a domino effect: the innovators are the ones exited by the adoption of new solutions, consequently their experience provide data to early adopters. If the product is still successful it reaches the majority of the customer base allowing the startups to win the competition.

1.3. Linking digital innovation and design thinking

In order to exploit digital transformation, the challenge is to ideate new solutions which leverage Information and Communication Technology (ICT) in the best way (Ueda et al., 2018). With Information Technology (IT) is meant all the hardware and software solutions that can help organization in management, operative and strategic activities (Thong & Yap, 1995). In ICT this idea is linked with the concept of communication, so the hardware and software solutions became able to communicate; now they can digitally exchange information and data within a network. Considering the development of new technologies, the new competition in the ICT realm is about understand people, society and technology; companies must deeply understand human behaviours and emotions, must consider future experiences and system and consequently design optimum service and the best product (Ueda et al., 2018). Regarding the design of new solutions, which usually has been focused on new product design and user interface, in the ICT realm the objective is the design of the user experience (UX). UX is about the experience of the user in using the digital solution, the right UX must activate a profound relationship between the end-user and the solution (Nedeltcheva & Shoikova, 2017), including feelings of empathy and satisfactions (Ueda et al., 2018). In this sense, design thinking can play a crucial role, indeed, according to its nature, it can provide the practices to reach the winning design solution. Design thinking coupled with UX design can lead to higher creativity, innovation and profitability (Nedeltcheva & Shoikova, 2017). Indeed, design thinking practices can help organization in understanding the true 'why' behind the solution and what it represents to the end-users, instead thinking about just produce a new product with a captivating design

(Ueda et al., 2018). Digital innovation, to be winning, must be focused on the end-users, indeed a lot of radical innovation such as eLearning platforms or social media are born from a human-centeredness approach. The participation of the end user in the innovation process becomes crucial, although is not already clear in which way (Kelestyn & Henfridsson, 2014).

1.3.1. Design thinking in the startups ecosystem

Entrepreneurs who found startups are seeking for innovative business model which can be successful in the market. Design thinking can help them in achieving their objectives, indeed it is process that can lead to innovation by imagining different solutions and bring them to life (Scott et al., 2016). The practice could help the startups to discover unexplicit end-users' needs, so the discover of new opportunities. Once that the opportunity has been identified, design thinking can help to ideate the right solution. According to Scott et al. (2016) the generation of new ideas is one of the most critical points of the in the process that leads to the foundation of a new company. Then, it is possible to refine the solutions based on the feedbacks gained thanks to the iterative test cycles with the potential end-users. Thus, the design thinking process can guide the entrepreneur to discover and create innovative profitable business model. Suroso et al. (2017) sustained this thesis as well; moreover, they assert that startups can use this method to make strategic planning of information systems. Many examples confirm these statements, for instance the use of design thinking practices for a creation of website that aims at increase customer satisfactions (Azarb & Park, 2016) or used by Apple to create hardware and software (Thomoke & Feinberg, 2012). There is a category of startups that have design as primary source of their development: Design-Intensive Startups (DIS); they are different on several dimensions from New-Technology Startups (NTS), which are firm which invests in emerging technologies as a key part of the product development, production or marketing (Park, 2005). According to Maeda (2015), despite a poor understanding of design entrepreneurship, in recent years designers have founded successful startups and Unicorns using a "design-centred" approach. These kind of startups have five main characteristics, which are the emerging issues that a designer-entrepreneur should consider in founding DIS: (i)

business idea based on passion, (ii) design as a transformative agent, (iii) Socio-cultural narratives in business models, (iv) leveraging social and local capital permanently and (v) context-dependent competitiveness (Colombo et al., 2017). Then, Colombo et al. (2017) developed a set of five creative tools which are useful to conceptualize DIS, they are meant to be educational material to designers which want to become entrepreneurs. Respectively to the characteristics, the tools are: (i) passion split – guide the designer to its passion in order to identify new business idea, (ii) experience navigator – allows to envision new tenement rules for the user, (iii) Socio capital cruiser – give suggestion of action to each kind of resource according to the level of criticality and accessibility, (iv) replicability evaluator – gain awareness about the business components and (v) innovation boxes – enables to visualize cluster of emerging trends.

1.3.2. Design thinking, agile product development and lean startup

Despite the common elements between design thinking, agile product development and lean startup approaches it is important understand that they are not the same concept. Considering the agile development methodology, it is possible to assert that it is characterized by iterative test cycles and focus on the end-users' needs (Beck et al., 2001); this is a similarity with design thinking practices, however the approach of the two is different. The iterative cycles aim to gain feedbacks and insights in the agile methodology, and the same happen in design thinking practices. Indeed, in the agile, there are predefined moments in which the team understand if their solution meets the requirement of the customer; then, once the feedback is obtained, the team modify the solution according to the insights gained (Annosi et al., 2018). The agile methodology is retrospective, in fact, the team follow a routine that help them to understand how they performed in the past iteration; the objective is to understand what is done in the right wat and how to correct the criticalities. The commonalities are present also between design thinking and lean startup approach. In fact, one of the main pillar of the lean approach is the rapid interaction through an Minimum Viable Product (MVP) to gain early feedbacks (Ries, 2011) and test the attractiveness of the solution (Ghezzi, 2018). The MVP is the version of the new product that the startup can built to collect the maximum amount

of validated learning (Ries, 2011). This approach is mainly used by startups which must early test the main assumptions of their idea, in order to improve the product and offer something that the market really wants. Lean startup approach is a toolbox for young companies which help to focus on just what the customer asks (Ries, 2011). According to Ghezzi (2018) the main pillars of this methodology are: (i) the formulation of falsifiable assumptions upon which the business idea is built, (ii) embedding these assumptions into a design business model, (iii) built an MVP in order to replicate the functions of the product and test the main assumptions of the business model, (iv) identify the potential end-users or "early evangelist" and propose the MVP to gain feedbacks and (v) test the product with multiple iterations to understand how to pursue the business idea: preserving, pivoting (undertaking a structured course of correction) or perishing. All three methodologies can be applied by companies in order to reach innovation, they try to structure and speed up the process of learning from the market and improve the solution. According to Micheli et al. (2019) the main difference between design thinking and agile and lean startup approaches, is in the fact that design thinking is not focused on activity within processes, rather it is a mindset and set the culture in an organization; it is a mix of activities, skills, orientations and logics. Moreover, a possible integration of these practices could allow to reach more benefits. In this sense, Nedeltcheva and Shoikova (2017) discuss about the integration of design thinking, agile product development and user experience design; the idea is that combining these approaches it is possible cover the weak points of a methodology with the strong points of the other ones. Particularly, considering a design thinking practice, the user experience design would help to better define the problem and generate new ideas by continuing designing, while agile product development would help the collaboration among the team and the testing on the potential solution. Although a higher level of effectiveness would be reached the level of complexity might be too high to handle, so, now, the framework remains in the theory realm.

1.3.3. Valuing digital technologies through design thinking

Design thinking can be useful in the development of digital technologies as well. There is evidence in support of this thesis, for instance, in the article published on

the Harvard Business Review by Emily Glassberg (2018), a senior director of data science at Coursera. In this article she describes the main step to undertake in order to build 'data product'. They are products which work thanks to the data and machine learning, and they are a powerful solution to respond to end-users' needs. She describes the life cycle of a 'data product', which starts with the identification of the opportunities to solve the needs of the customers, then the creation of an initial version which ones is built it is tested to evaluate its impact. Already at this point it is possible to observe many similarities with design thinking practices; moreover, Glassberg asserts that in order to manage the complexity given by data component companies must create cross-functional teams and enhance collaboration prioritizing the product opportunities. She also explains the importance to early built the product, that even if it simple accelerate both testing and the collection of valuable data. Chen er al. (2017) illustrates a method composed of ten steps with which design thinking sustains the development of digital technologies, in particular the development of big data projects. This is necessary because the majority of the project related to big data ends up with failure. Big data is often associate with digital transformation, it represents opportunities in the value discovery, so in the extracting valuable insight from huge amount of data that companies have. Thanks to the value extracted is possible to obtain new level of competitive advantage, for instance in management of the operations or in the relationship with the customers. The big data projects often fail because there are not already methods which help companies in manage the complexity of these projects. According to the authors design thinking can help to deliver these projects, indeed its capability to manage wicked problems by co-evolving both problems and solutions may generate a large number of scenarios. Another value added of design thinking to the data analysis is given by the capability to use emotions and logic during the process; and this results in a less biased outcome (Martin, 2017). In fact, the data cannot be a standalone truth, because they are based on the past; and since the past does not replicate exactly in the future the adding of logic and emotions must be in the equations to analyze data in the right way (Martin, 2017). Design thinking can be really indicated in the developing of new solutions, both products and services, in case in which there is a high level of uncertainty, as, for instance, where the project are related to new and relatively unknown technologies. In this sense, Moon et al. developed a framework based on design thinking practices, the Morphological Future Envisioning (Morf-Vison), a model which helps companies

in the first phases, when the problem in identified but solution on how to solve it are still not clear. It also stimulates imagination and creativity by thinking about potential solutions which are not strongly linked to the context of the problem (Moon et al. 2019). This aspect of design thinking is useful considering that with the development of new technologies, for instance Internet of Things (IoT), many markets have been completely change and companies needs to adequate to new standards. Indeed, these technologies represent a true challenge for companies since they must quickly adapt to the new competitions in order to survive. The application of design thinking practices might help companies to implement new technologies and reinterpret their current proposal to the market. A further contribution of the use of design thinking for the development of digital technologies comes from Sharma et al. (2015) regarding the IoT fields. The practitioners tried to work on the early stages of the design thinking processes, in understanding the problem and the framing of the problem. They propose three subcomponents in addition of the traditional design thinking process: (i) each IoT element is represented by props with the relative augmented information, (ii) point of interest are marked out as places where the information is generated and (iii) an empathy experience where a person moves person use the props and narrate a story. The exercise is useful to give a collective picture of the problem to the team and allow them to consider almost every aspect that might lead to the discover of new direction for the project.

1.3.4. Empowering design thinking through digital technologies

As emerged from the literature, it is possible to assert that design thinking can facilitate the adoption of the digital technologies in the companies and improve their effectiveness. It is in the interest of this work investigate about this relationship, but in the other direction. Thus, try to understand how digital technologies, such as AI, IoT, big data and so on, can enhance design thinking practices. There are few contributions around this topic, and this leave room to further investigation. It is of interest understanding (i) which phases of the design thinking process could be more impacted by this digital revolution, (ii) which are the most suited technologies to sustain design thinking practices and in which way

and if (iii) is the relationship of these two realms effective in the results. In her article on the Harvard Business Review Glassberg (2018) asserts that the potential of machine learning and big data can help to grasp insight from data and better understand users' needs. This can help companies to win the competition by increase the user engagement. There are many examples such as Google search or Amazon product recommendations that helped these tech giants to be more successful on the market. However, according to the author, thanks to the spread of these technologies also companies with smaller dimension are investing in their own data-powered products. For instance, the educational platform Coursera, the company in which Glassberg has the role of senior director data science, uses machine learning to helps users in finding the best content to reach their leaning goals. Another extremely interesting opportunities is in the creative spaces (Aschehoug et al., 2018), which are a solutions for all that organizations which want to implement open innovation. Open innovation can be defined as the inflows and outflows of knowledge which aim at reaching innovation (Chesbrough, 2006). In these spaces design thinking methodologies can be applied, they can be closed or open communities in which the objective is to innovate. In these realties, in addition to the tools equipment, it is possible to use the CAD software, IoT solutions, and other technologies such as virtual reality (VR) and augmented reality (AR). Regarding the latter solutions, VR and AR, it is interesting understand how virtual worlds can enhance real world innovation, considering the emphasis received in the last period, for instance in the metaverse provided by Meta. The environment of virtual worlds has been described as engines of creation that provide the freedom to experiment and lead to unprecedented rates of innovation (Ondrejka, 2007). In these worlds there are tools that encourage users to create iteratively and interactively almost everything imaginable. It is also possible foster the collaboration and so the co-innovations activities thanks to the avatars which can collaborate in the same environment; in this sense it could facilitate not only the collaboration of the team, but also of the end-users. Moreover, with a common hardware and an internet connection it is possible to work in a virtual environment form remote. Another opportunity is represented by the rapid prototyping with the use of 3D-printing technologies, which are capable to speed up the physical realization of a product. However, the process is not fast enough to satisfy the pace of design thinking projects and moreover there is a scarcity of the materials availability (Lisi, 2015). Overall, it is possible to assert that the sustain of digital

technologies to design thinking practices is still in the early stages, but with the future development of these technologies at least some part of design thinking processes might be enhanced.

1.3.5. Artificial intelligence and its relationship with design thinking

Artificial Intelligence was born in 1950 with Alan Turing who introduces the Alan Turing test, a test in which a human does not know if the entity with which he/she interacts is a human or a machine. The machine passes the test if convince the human that he/she is interacting with another human. This is the starting point of AI over the years, which have a period without a real development due to the low number of successes of the technology. In the recent years the number of the investments increased thanks to the new achievement and the AI research area grew year by year. Brunette (2017) asserts that the early definition of AI was simply "the intelligence exhibit by machines". Nowadays, the focus of AI is shifted to modelling human intelligence, improving computational tools, media and advancing goal-oriented processing for complex interactive environments. There is not a common definition among the practitioners, according to the definition by Osservatorio Artificial Intelligence of the Politecnico di Milano, the definition of artificial intelligence is: "artificial intelligence is the branch of computer science that studies the development of hardware and software systems with specific capabilities typical of human beings and able to autonomously pursue a defined goal by taking decisions that, until then, were usually entrusted to human beings". The capabilities of typical of human beings are listen and understand the meaning, recognize what is present in a certain image, learning and reasoning, interacting socially and physically. Looking at the current applications of AI algorithms, the classes of solutions, according to the Osservatorio AI of the Politecnico di Milano, are as follows:

- *Autonomous vehicles*: autonomous means of transport, they either driving on the roads or navigating on the water, or even flying. They are able to perceive the external environment and identify the correct manoeuvres required to adapt to that environment;

- *Autonomous robots*: robot that can move themselves or some parts and manipulate objects or execute other actions without the intervention of humans. They learn from their surroundings and adapt according to situation even if is not foreseen or programmed;
- *Intelligent objects*: object able to perform actions and make decisions without requesting the intervention of humans. They interact with the surrounding environment using sensors and actuators. They are capable of learning from the habits and actions of people that interact with them;
- *Virtual assistants or chatbots*: software agents able to perform actions or provide services to a human interlocutor. They interact via written or spoken natural language and understand commands or requests;
- *Recommendation*: this solution aims at showing the preferences, interests or general decisions taken by the users. This according to the information directly or indirectly collected from the user;
- *Image processing*: this solution analyze images or video for recognising people, animals and objects in the image or to generally extract information;
- *Language processing*: used for various purposes such as content comprehension, to translation, to producing text autonomously on data and documents supplied as input;
- *Intelligent data processing*: this solution use AI to extract insights from structured and non-structured data: It triggers the consequent actions: predictive analysis, monitoring & control, pattern discovery, contents and design creation.

While AI is pioneering in using advanced mathematics and technologies to grasp knowledge from large data bases, identify patterns and transform activity in many fields. Design thinking is involved in how people think and act, both individually and in group, to achieve objectives. The two fields need to work need to work together to create synergies and enhance each other. This because both are committed to leaning, understanding and improving the situation that they address with purpose (Brunette, 2017). Their similarities and differences highlight the opportunity and need for collaboration. On one hand, AI could help design thinking to be more efficient and effective, and, on the other hand, design thinking could help AI became more human centred and contextual.

According to Nelson (2018) design thinking principles could be effective for companies which want to adopt artificial intelligence (AI) solutions. Gueszca, chief data scientist at Deloitte Consulting, asserts that an AI revolution is underway, but it needs to be complemented with a design revolution. Indeed, although AI could be the solution to many problems, before its implementation is important deeply understand the problem and people; at the end of the day AI helps to solve problems that people face (Pratiher, 2018). The author of the article asserts that the design thinking principles can be applied to approach deep learning because it provides a framework and steps to a process that otherwise is a complicated process with many stages. It helps to integrate the human centred way of looking solving problems in AI and emphasizing an iterative way of building neural network like designers create design. Another example is provided by Ala-Kitual (2017), who reports the use of design thinking practices in the development of an AI model in healthcare and social service. Thanks to design thinking they were able to identify the major criticalities of the problem and thus give the pillars upon which the AI is developed.

On the other hand, AI according to its characteristics can enhance the design thinking practices. An example is given by the computational creativity, which allows computer to generate creative output like humans (Lisi, 2015). The computational creativity aims at replicating a characteristic which belong just to human; and this would obviously enhance the capability to design new solutions. The interest in this field is increasing over the years and there are some examples of artwork done by machine sold at really high price. The AI machine, after having ingest tone of data regarding artworks, proposed a work create by itself. One of the main characteristics of AI is the capability to accelerate the first phases of the design thinking process. According to Raisch (2021) AI-based solution can automate or augment activities inside organizations. Particularly, automation implies that machines take over a human task while augmentation means that humans collaborate closely with machines to perform a task. In design thinking practices it might be possible, with the sustain of AI, automate some process such as the data analysis and augmented the ideation process. Considering this, the integration of automation and augmentation could enable synergies which leads to additional benefits and consequently to superior firm performances (Raisch, 2021). In this sense, according to Cautela et al. (2019), the main effort will shift from the "context

of the design problem" to the "context of the solutions"; managers will dedicate more attention to the activities related to the ideation and the creativity will be applied less to the analysis and more to proposing new solutions. This is due to the ability of AI in interpolating different types of datasets and data sources to gain insights with statistical significance faster than before. In this sense AI is better than human at interpreting users' behaviours by analyzing users' behaviours from social networks, websites, sensors and so on (Cautela et al.; 2019). This is helpful to remove biases and shift the focus from the understanding of the problem to the solution of the problem. In this sense, innovators can utilize this set of insights in their generation of abductive hypothesis regardless of their previous mental model or knowledge (Garubio et al., 2021). Indeed, abductive reasoning is often generated from unusual and surprising observations which are not reachable by induction or deduction alone. In this sense, AI can give new and interesting insights which do not rely just on the experience of the innovators which is necessarily limited both in scale and scope (Garubio et al., 2021). Verganti et al. (2020) analyze the cases of Netflix an Airbnb and their use of AI in relation to the evolution of design and innovation in companies. According to the authors AI enhance design thinking practices allowing them to overcome many past limitations of human-centred design: improve the scalability of the process, broaden the scope and enhance the ability to learn during the process. Moreover, thanks to AI, it is possible to design a personalize the offer to each person, meaning that the maximum level of the user centred is reached. To capture the potential of AI, which can accelerate the rate of innovation for companies, manager need to rethink their innovation process. they need to understand that the role of humans is not to the develop full solutions, rather they must understand which innovation problems are meaningful, framing the innovation effort and set up the software (Verganti et al., 2020).

2 Research Methodology

The following section describes in detail the step followed to conduct the present research. First, in the paragraph 2.1 the research goals have been formalized. Consequently, in paragraph 2.2, it is presented the theorical framework which led at identifying the objective of this research. Finally, in 2.3, the empirical framework is outlined. Overall, it is described in detail the process which led to the results of the present work.

2.1. Research goals

The work aims better explore the environment of digital startups; understanding the relationship between these young enterprises and the design thinking practices. Firstly, considering that the research line related to digital startups is still not mature, the investigation aims at clarifying the presence of digital startups related to design thinking topics. This has led to the map of the current environment of digital startups which can support the subject, highlighting how the scenario is structured and characterized. Therefore, this led to the first research question:

i. How is structured the current design thinking startup ecosystem?

The first step of the research process ended with the creation of a database composed of 612 startups which can be directly or indirectly related to design thinking. Indeed, all the startups which can potentially support the practices were considered without distinguish if the company has a clear link with the subject or if it is unaware of the potential support of its service. The result can potentially give several benefits to practitioners and academics. For instance, it is possible for academics to understand which the main approaches are supported by these digital ventures; and, on the other hand, for practitioners it can be useful understand which service exist that potentially can improve their design thinking practices. Considering the outcome of this first analysis, regarding the technology adopted, a further analysis was performed. Indeed, the majority of the startups which base their service on an emerging technology use artificial intelligence. From this point, the second question of this research can be formulated as follow:

ii. How artificial intelligence can support design thinking practices?

The large adoption of AI by these startups makes clear that there could be a connection between the capability of AI and the design thinking process. The studies around this topic are still few, consequently has been decided to investigate about this topic with the analysis of some business case. The companies which belong to the database structured to answer to the first research question were contacted in order to schedule an interview. Among these eight companies accept to be interviewed and a coding analysis has been performed. The result led to a formulation of proposition which aims at enriching the existing literature and give new insight to this field which is still unexplored.

2.2. Theoretical framework

A literature review has been carried out in order to get familiar with the theme of design thinking, its history, its development over the years and its adoption. This step led to the clarification of the scope of analysis of the work as well as the missing point in the literature. From this point it has been decided to explore the relationship between digital entrepreneurship and design thinking, and, consequently, a selection of papers related to both fields has been performed. The research has been performed on scopus.com which find academic articles considering key words. In this sese, the key word used were 'design thinking' and 'digital entrepreneurship' within the title, abstract or keywords. From a first list of articles an important part was discarder after reading the abstract because they were not in line with the research question. Then the remaining articles have been read and summarized, this led to the literature review present in the chapter XX. This process allowed to answer to the first question and mapping the digital startup ecosystem. After this step the second research question emerged. Thus, a complete analysis of the literature which investigates the relationship between design thinking and digital startups has been conducted. The key words used on Scopus.com were the combination between "artificial intelligence" and "design thinking" or "design". Around these topics, there are few theoretical contributions: the main studies were summed up in the literature review, were also a description of artificial intelligence and its capability is provided.

2.3. Empirical framework

The following paragraph aims at illustrating the steps followed to answer the first research questions emerged from the theoretical framework and the second one which came from the description of the current ecosystem of the digital startups related to design thinking.

2.3.1. Mapping the design thinking ecosystem

The first part of this research aims to illustrate the startup ecosystem related to the theme of design thinking. Desk research has been performed to understand the current scenario of the theme under analysis; and for each company several variables has been recorded in a database in order to categorize and describe them. Crunchbase.com is the starting point of this research, it is the leading platform for finding business information about private and public companies; moreover, it includes investments and funding information, founding members and individuals in leadership positions, mergers and acquisition and other useful information. In order to have an initial sample of potentially fitting companies to the theme under analysis some filters have been set.

The filters are as follow:

- The startups must be founded after 1st January 2012;
- The startups must have received at least one fund;
- The startups must have received the last funding after 1st January 2015;

Crunchbase.com categorized the company based on 'tags', in this sense to filter the companies only tags related to the theme under analysis have been selected. The tags and the constrains have been chosen together with the supervisor of this work. The tags selected are as follow: UX design, web design, human-computer interaction, industrial design, graphic design, product design, mechanical design, social innovation, interior design, furniture, usability testing, CAD, 3D technology, augmented reality, video chat, 3D printing, creative agency, video editing, collaboration, innovation management, product management, project management, intellectual property, management consulting, advanced materials, document management, meeting software, artificial intelligence. The total amount of startups

in line with these criteria was 9,148. At the time the extraction from crucnchbase.com was performed, a list of information regarding the company were downloaded. The information collected are as follow:

- Organization name;
- Official website;
- Tag categories: which is the tag with which cruchbase.com categorize the organizations;
- Headquarters locations;
- Description of the startup;
- Number of employees;
- Number of founders;
- Founding date;
- Number of funding rounds;
- Last funding amount;
- Last funding date;
- Total funding amount collected;
- Number of investors;
- Contacts.

The outcome of the downloaded is a .csv document which include all the mentioned above information. The file was organized and cleaned with Excel; this led to the creation of a first draft of the database. Then, each startup website was observed trying to understand if the organization can effectively support design thinking process or not. A large portion of the stratups were discarded because they did not meet the requirements. A tag was assigned to each startup, particularly: (i) 'yes' if the startup was considered in line, (ii) 'no' if the startup was not in line and (iii) '???' in case the result was not clear. In the first round the results were: 708 'yes', 69 '???' and 8371 'no'. A second round of observations had been executed considering the remaining 777 startups. The last round was performed together with the supervisor in order to reduce the bias in the results; the final outcome was of 612 startups which can support design thinking practices. These startups were further analyzed in order to enriching the database and give a complete description of the startup. All the variables considered for each company are described in the following Table XX:

Category	Variables	Description
General	Company name	Name of the organization
	Website URL	Website of the organisation
	Description	Short description of the organization
Headquarters	City	City where the headquarters is located
	Region	Region where the headquarter is located
	Country	Country where the continent is located
	Continent	Continent where the company is located
Organization	Employees	Number of the employees which work in the organization
	Founders	Number of funders
Funding	Founding date	Date on which the company was founded
	Funding round	Number of funding rounds carried by the startup
	Last funding data	Date on which the startup received the last funding
	Last funding amount	Last funding amount received by the organization
	Total funding amount	Total funding amount received by the company
	Number of investors	Total number of investors who have financed the startup
Categories	Categories Tags	Tag used by cruchbase.com to categorize the organization
Technological families	Artificial Intelligence	Presence of aritificial intelligence in the service offered by the company
	Internet of things	Presence of internet of things in the service offered by the company
	Cloud computing	Presence of cloud computing in the services offered by the company
	Augmented reality	Presence of augmented reality in the service offered by the company
	Big data	Presence of big data in the service offered by the company
Design thinking	Approach	Choice of one of the four approaches (creative problem-solving, sprint execution, creative confidence and innovation of meaning) described in the paragraph 1.1.6.
	Metaphases	Binary recording of the coverage with the startup's offering of the metaphases described in the paragraph 1.1.3.
Business Model	Offering	Binary recording between product and service
	Pricing	Recording of the pricing strategy expressed among versioning, demo, fixed price, freemium and 'send an email'
Collaboration	Partnership with consulting companies	Presence of the logo of consulting companies on the website of the organization
Others	Contacts	Email of the startup
	Social media references	Social media links of the company

Table 1: Variables collected in the startup mapping

Once the database has been completed, an analysis has been performed: it allows to generate graphs which illustrate the whole ecosystem of digital startups which support design thinking practices. To the graphs considerations were added in order to complete the description an enrich the insights: for instance, it is possible to understand which design thinking approach is more sustained by digital companies or which design thinking metaphases are more supported. The results are illustrated in the next chapter and are clustered as follow:

- Funding to digital startups;
- Organizational structure;
- Design thinking approaches;
- Metaphases supported by digital startups;
- Technological families;
- Business model of digital startups.

2.3.2. Business cases

From the mapping of the digital startups ecosystem, particularly in the cluster related to the technological families, it emerged a dominant use of AI by startups to sustain design thinking practices. Indeed, the 92% of the companies of which the service rely at least on one technology use AI. From this point the second question of this work:

(ii) 'How artificial intelligence can support design thinking practices?'.

To answer the question and deepen the first analysis eight interviews have been conducted. These startups accepted to be interviewed and they represent a complete cluster of offering; indeed, each metaphase is covered at least from one digital company. In the following table is it possible to see the metaphases covered by each startups.

	Sensing and empathizing	Interpreting and framing	Team building and task management	Ideating and conceiving	Collaborating and codesigning	Prototyping and learning	Launching and measuring
S1		***		***			
S2						***	***
S3		***	***	***	***		
S4		***		***	***	***	
S5	***	***					***
S6	***	***		***			***
S7	***	***		***			
S8		***		***			

Table 2 : Metaphases covered by startups

Moreover, the eight digital startups represent a good sample for the design thinking approaches as well. Unfortunately, none of the seven companies which adopt an innovation of meaning approach with the use of AI accepted to be interviewed. However, the other three approaches are present almost in a balance way. Furthermore, considering the geographical dispersion of digital starutps related to design thinking, the startups interviewed comes from different part of the world enriching the research thanks to different point of view related to AI and its application. The limited dimension of these companies (none of them exceed the 50 employees) gives the opportunity to interview people who cover relevant position inside the company; this allow to grasp what is really the strategic use of AI inside

the company and which are the ambition of the digital startups. An overview of these characteristics is present in the following Table 3:

	Design thinking approach	Headquarter location	Role of the interviewed
S1	Creative confidence	Houston, USA	CMO – Chief Marketing Officer
S2	Sprint execution	Vilnius, Lithuania	CMO – Chief Marketing Officer
S3	Creative confidence	Boston, USA	CEO – Chief Executive Officer
S4	Sprint execution	Edinburgh, Scotland	CSO – Chief Scientist Officer
S5	Creative problem-solving	Sundsva, Sweden	CPO – Chief Product Officer
S6	Creative problem-solving	Austin, USA	GM - Growth Manager
S7	Creative Confidence	New York, USA	CTO – Chief Technology Officer
S8	Creative problem-solving	Mumbai, India	CEO – Chief Executive Officer

Table 3 : Heterogeneity of the sample

An outlook of these startups is provided below in the Table 4 while further details on the companies analyzed are provided in the annex.

	General description *(What the statup offer and to whom)*	**Specific Solution** *(What specific solution is provided to address the DT phase/phases?)*	**Overall changes in DT** *(What changes AI is providing to DT?)*
S1	The AI platform learns from human experts and extracts key information from large unstructured data assets to save time, cost and to de-risk business decisions	The software us based on Intelligent Document Processing (IDP): It uses AI technologies such as natural language processing (NLP), Computer Vision, deep learning and machine learning (ML) to classify, categorize, and extract relevant information, and validate the extracted data.	They use AI to extract investigate huge data set and extract insights based on past experiences of the companies. This supports the design of new solution by taking advantage of all the success and errors done in the past.
S2	It enables to evaluate the new design for marketers, UX researchers and designers to validate the concepts for performance during the design phase.	Predictive eye tracking: the AI recognizes particular patterns in user attention flow and systematizes them with heatmaps.	The software is useful to understand the effectiveness of the project before deploying it. It enables AI to make predictions on what will attract the most interest on your new design.
S3	Provide a platform where users practice analysing information, coming up with solutions to issues, and learning both independently and in groups.	When users ask questions, the platform gather them, rate them, and AI measures the quality of their content through machine learning. It also tracks every team member thought process, measuring the quality of ideas teams choose to focus and automatically maps thinking.	AI allows to structure the brainstorming phase, allowing to understand how the team approach the problem and how they try to solve it. AI synthesize all the information related to the ideation phase and value the different contribution.
S4	It uses AI to rapidly examine options for design, routing, installation and mitigation of linear infrastructure.	Optioneer is based on AI and cloud technologies. It integrates constraints and models from all disciplines to give a complete view of the project working with a multi-criteria analysis.	It lets project teams automate the existing design process capturing high level of engineering detail and iterate through thousands of design options to find the best ones.
S5	It is a platform which allow to get access to business-critical information in the retail industry. It creates holistic analysis, online -to-offline.	They are a computer vision company based on 2D cameras. Thanks to AI they capture data and then anonymize them. Then, with machine learning it calculates insights.	It allows to grasp more valuable insights and export and merge them with existing data sourcing. It is useful to conduct experiments and get the results to design more profitable strategies.
S6	The tool enables organizations to build AI on top of it. Using the software and its feature base they could build different logics and statements	It is a feature-oriented database platform that powers real-time analytics and machine learning applications by simultaneously executing low-latency, high throughput, and highly concurrent workloads	It helps the customers to implement AI solutions to better manage their data and access in a fast way to new insights. They can help companies at understanding what their customer really wants, especially in terms of customer experience use cases.
S7	The platform reads and analyses articles, documents and other textual data, so that you can learn more with less time and uncover hidden insights.	It is a web app based on machine learning and deep learning. It uses natural language processing algorithms to read articles, categorize them and generates insights.	It helps to rationalize information overload to make easier the creation of knowledge. It is useful to find pattern among different articles and discover connection. Once the knowledge is generated is shared among the team giving some suggestions to support the ideation phase.
S8	It helps to make data-backed decisions by translating complex datasets into simple language.	The software use AI to analyse any source of data. Then, it is possible to ask questions to a conversation interface based on natural language processing.	It allows to make sense of huge data set without having assistance from the IT teams thanks to the possibility to ask questions in natural language. The software provides personalized and relevant answers in real time allowing the quick generation of new insights.

Table 4 : AI solutions and the impact on DT

The interviews had a duration of 30-45 minutes, in which the purpose of the inquiry was first presented, then a semi-structured interview was performed in order to explore the use of AI by these companies and how they can support design thinking practices. Consequently, the interviews were written down in documents to analyze them. The semi-structured interviews use open-ended questions followed by more detailed questions to obtain case by case insights: for instance, digital startups which cover different metaphases or which use in a different way AI received different questions. The interview followed a protocol chosen according with the supervisor of this work: at the beginning a brief description of the project was provided to the interviewed; then, it was asked to describe how AI is utilized in the service which is provided to the customers. Consequently, a question related to the main benefit that the technology give to the customer was asked. The last predefined question aimed at understanding how the service provided by the digital startups can help innovation or the designing of a new concept in companies. Then according to the insights emerged and the characteristic of the company under analysis some main points of interest were explored. The objective is to understand how the service can effectively support steps of the design thinking process. Considering that some of the interviewed did not know design thinking practices, each of the questions aimed at identifying where potentially AI creates value for the innovation process of the customers.

In order to maximize the accuracy of the interviews, informants bias have been addressed in several ways. (i) As suggested by Eisenhardt (1989), to encourage the maximum level of honestly, the anonymity has been guaranteed. (ii) To the respondents were asked open-ended questions to give the opportunity to space in the answers as they prefer (Koriat & Goldsmith, 2000). (iii) Informants with different perspective and cultural background have been interviewed as "knowledgeable agent" (Gioia et. al, 2012). In this sense, if it is considered that the informants were interest in solving the inquiry, the reliability and the accuracy of the insights increase (Ozcan & Eisenhardt, 2009; Kuzmar et al., 1993). (iv) In order to guarantee accurate information techniques such as event tracking and non-directing questioning, the observstions have been used (Martin & Eisenhardt, 2010) and comments were notated on a "field notes" (Eisenhardt, 1989).

2.3.3. Data analysis

Once all the interviews were transcribed a coding procedure was performed according to the Gioia methodology (2012): it consists in analyzing line by line each interview, looking for specific insights, in order to define "concepts". A specific label was assigned to each of this concept, by using exactly the same words in order to stay in line with the message of the interviewed or summing up the principal meaning. The next step consists in categorized a group together labels according to the sphere of pertinence; so, the label which belong to same category were clustered together. With this step it was possible to triangulate the evidence collected with the theorical realms of how artificial intelligence supports design thinking practices, trying to understand if the concepts developed was consistent with the literature and it allows to explain the phenomena observed (Gioia et al., 2012). In this sense, there are two main relevant points: on one hand, understand if the evidence emerged confirmed previous research; on the other hand, if it is possible to enrich the current literature with new concept were discovered. In particular, according to Eisenhardt (1989), it was fundamental compare the intermediate result with existing literature and previous research about the topic. This allowed to increase the validity and the accuracy of the research. The main difficulties in presenting the results of a research based on case study is in staying in the spatial constrain while propose emergent theory as well as support the existing literature (Eisenhard & Graebner, 2007). To present the results in the best wat a "zoom-in" approach is used (Gioia et al., 2012): in this sense, some quoted from the interviewed introduce the concept before arriving to the theoretical proposition. The results are provided in the Chapter XX. The reverse structure is present in the Chapter XX in which starting from the proposition previously illustrated, the relative contributions to the existing literature as well the new implications are discussed.

3 Results

This chapter presents the results achieved by analyzing of data from crunchbase.com and from the interview. First, a series of charts are presented to fully describe the ecosystem of the startups which support the design thinking practices. Then, in 3.2, through the analysis of the interviews five main propositions are formulated; these five statements explain how the AI support the design thinking processes.

3.1. Mapping the design startup ecosystem

In Fig 3 it is possible to see the geographic distribution of the startup ecosystem, in particular the location of each headquarters. As it was possible to imagine the United States are the most flourishing territory with 256 companies representing 42% of the 612 companies which compose the sample. In particular the startups are located in San Francisco Bay (72 out the total of the US ones): this is mostly due to the presence of the Stanford University which is where the concept of design of thinking was born. From the mapping of the headquarters, it emerges that the presence of design thinking startups is rising all over the world, they are in each continent and the number of these companies is increasing year after year.

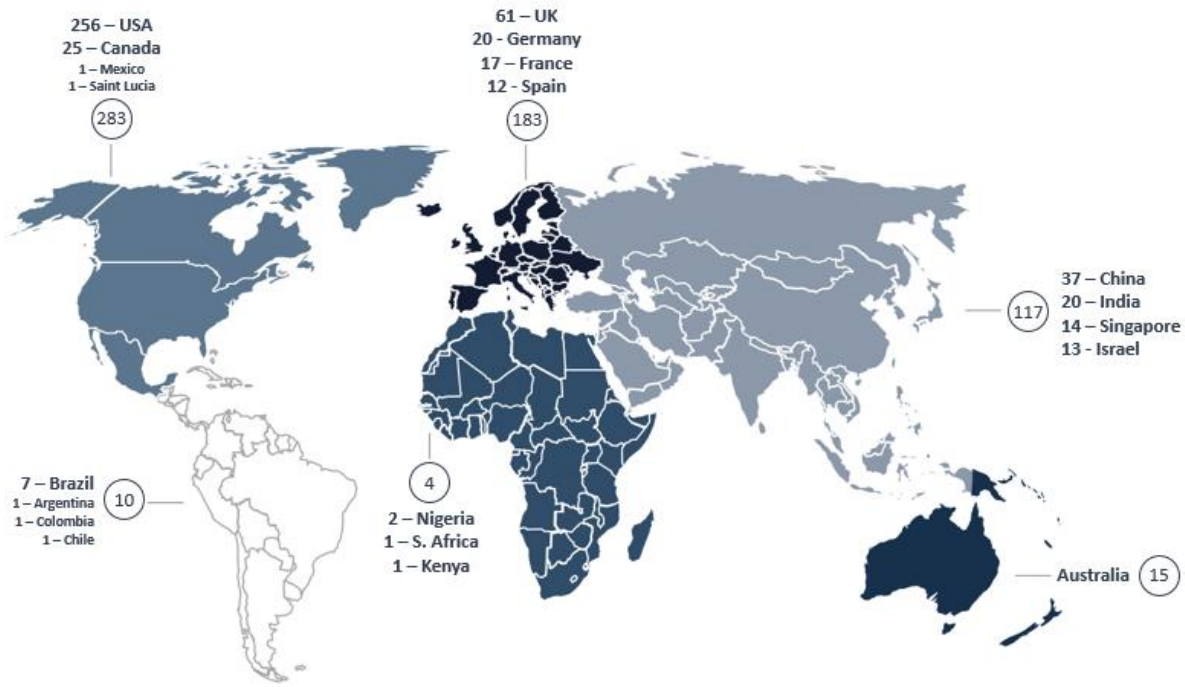

Figure 3 : Geographic distribution of design thinking startups

The sample of startups is located as follows:

- 283 startups in North America, with 256 american startups founded which is the largest number among all the nations;
- 183 startups in Europe, which confirm itself as the second continent as regards the design thinking startups founded. Here the first nation by posting is the UK with 61 startups, followed by Germany (20) and France (17) while Italy is sixth with 8 startups;
- At the third position there is Asia with 117 startups of which the most are located in China (37) then India (14), Singapore (14); showing a constant increase over the years.
- 15 in Oceania all in Austalia;
- 10 in South America, the most in Brazil with 7
- In the last position there is Africa with 4 startups, the most (2) in Nigeria.

The design thinking is becoming a global phenomenon and the number startups related to this field are constantly increases all over the world. Regarding the cities the first is San Francisco with 51, then we have London with 38 and New York third with 32; it is really interesting notice that the second one is a European city meaning

that more and more ventures are born away from USA and confirming a growing diffusion of design thinking practices.

Italy, as already mentioned, is positioned sixth among the European ones with 8 ventures in 5 different regions: Lombardia with 4 and Piemonte, Sardegna, Puglia and Sicilia each with 1.

3.1.1. Funding to design thinking startups

To better understand the financing situation of design thinking startups, the total funding amount raised by a venture was plotted against the last founding amount. In the Fig 4 it is possible to observe the results. The average raised by each company is highly influenced by the top 13 for total funding amounts, these startups in fact raised at least 70 million dollars during their life cycle. The list is as follows:

- *Thoughspot*: a business intelligence platform that helps anyone explore, analyze, and share real-time business analytics data easily;
- *Gong*: a revenue intelligence platform that delivers insights at scale;
- *Quantum Metric*: a cross-device digital intelligence platform that is designed to identify high-value revenue opportunities;
- *Sema4*: it uses artificial intelligence and machine learning to analyze patient data to provide insights to transform the practice of medicine;
- *Front*: it is the leading customer communication platform that transforms work into impact;
- *Tuya*: an IOT solutions provider that helps manufacturers develop their app and bring their product to market and at competitive prices;
- *Hopin*: a live virtual events platform that enables attendees to connect, learn, and interact with people anywhere;
- *Veritone*: has created a future-proof AI platform that comprehends and transforms multiple forms of data to create actionable intelligence;
- *Domino*: it is the world's leading Enterprise Data Science Platform, powering data science at over 20% of the Fortune 100;
- *Kakao Enterprise*: it is specialized in providing AI technology-based working platforms and services.

- *Kinetica*: it combines historical and streaming data analysis with powerful location intelligence and AI for instant results;
- *Guru*: a knowledge management solution that keeps customer-facing teams up-to-date, consistent, and confident;
- *Zego*: a provider of stable and high-quality cloud streaming services for real-time audio and video communications.

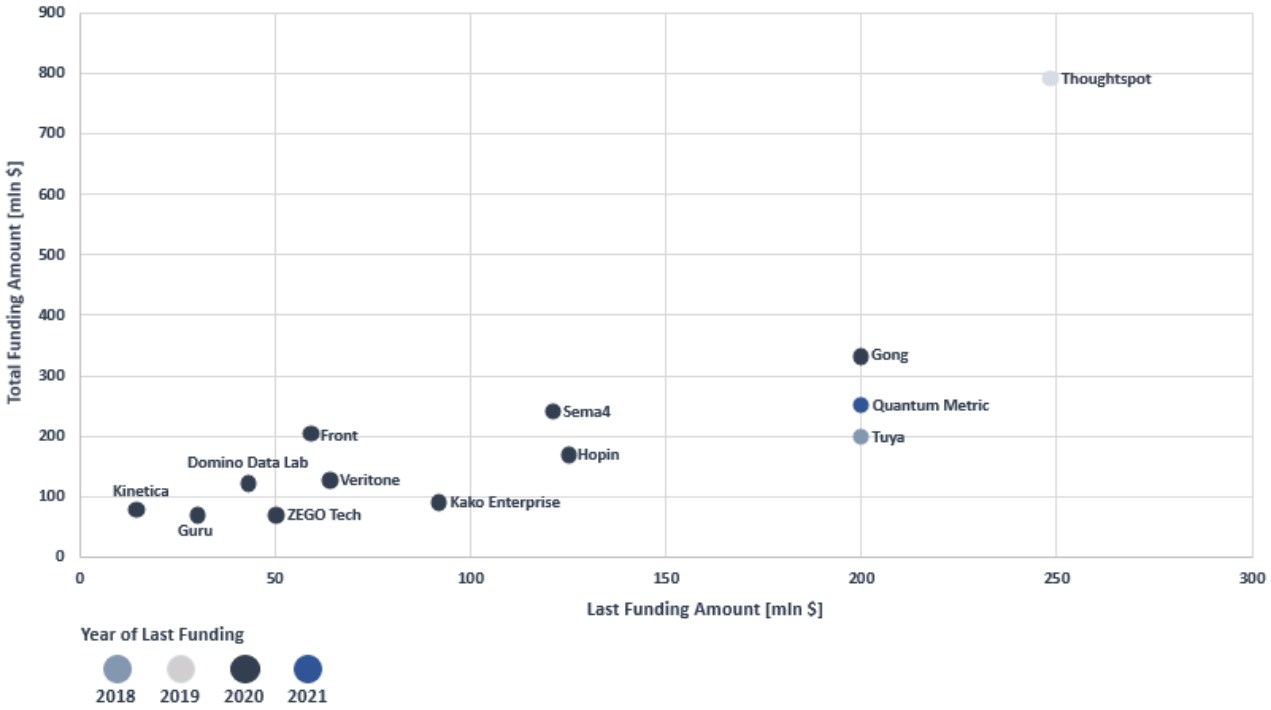

Figure 4 : Most funded startup in the design thinking ecosystem

Without considering the overall investments of the above-mentioned startups, the average funding per ventures decreases from 9.4 million dollars to 5.0 million dollars. This confirms how the top 13 startups have a strong influence on the overall average. However, the interest of the investors in this kind of startups seems to increase over the years, in fact without considering the top 13 still 159 ventures succeed to complete at least a series C or above.

Moreover, to understand the confidence of the investor an analysis of the last year funding of the overall ecosystem has been performed. As it possible to see in the Fig 5, most of the startups raised founds in the last years. The 47% (293 startups)

received their last investment after 2020 and 27,9% (171) in the 2019. From the figure it emerges a clear positive trend over the years, showing an increasing maturity of the design thinking startups ecosystem.

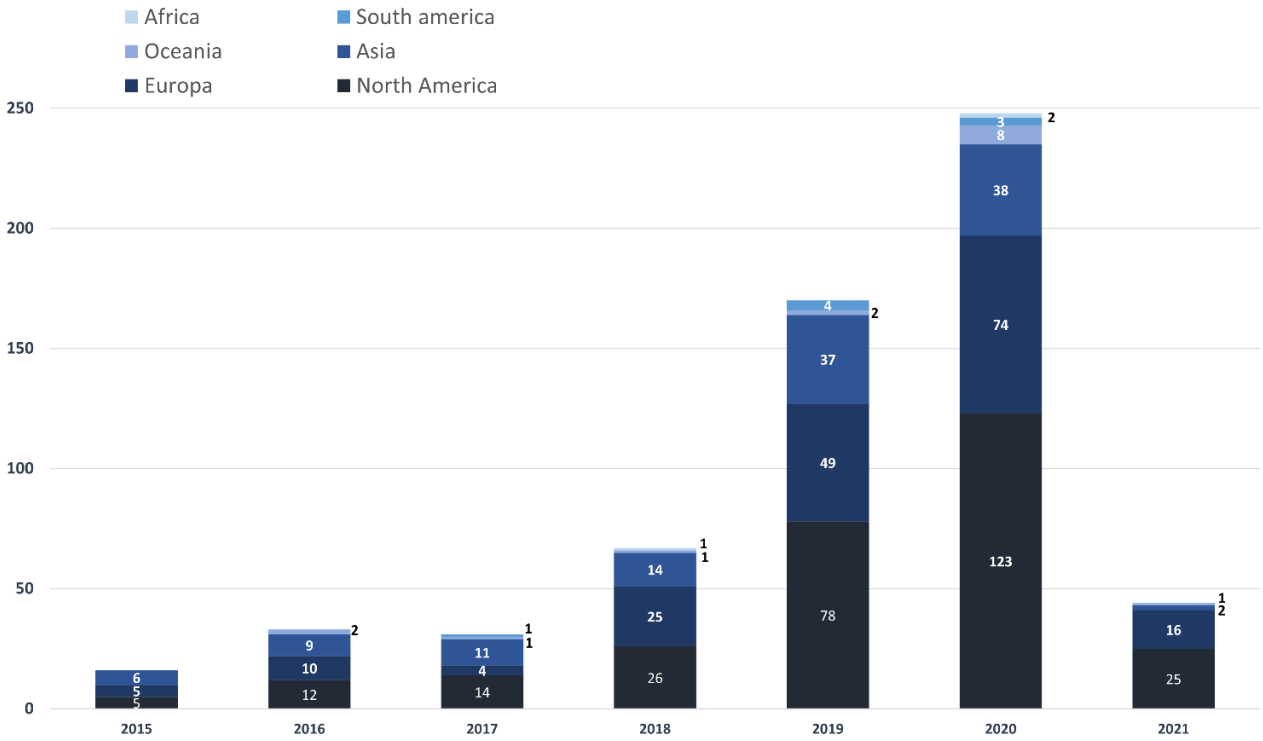

Figure 5 : Last year funding of the design thinking startups

Looking at the Fig 5 it is possible to confirm the spread all over the world of the foundation of design thinking startups. From 2016 till 2021 is possible to notice an increase of the number of foundations also in Oceania, South America, and Africa. However, the influence of the USA remains dominant and constant over the years; Europe and Asia keep a strong position as well. In particular:

- Design thinking startups in North America keep gain funds in a consistent way. The lowest value is in 2015 with 31%, then from 2016 to the start of 2021 the lowest value is 38% (2017) till reaching the 50.5% (2020-beginning2021).
- Europe and Asia follow North America over the years, confirming their consideration in design thinking practices. In the early years there is a balance between the two continents, while in the last years there is quick

increase in the European ones. Particularly in 2020-beginning2021 where there are 30.7% of the total startups with the headquarters in Europe against the 13.6% of ventures located in Asia.

- Regarding Oceania, South America, and Africa the presence is considerably lower. However, it is important notice their consistence over the years.

3.1.2. Organizational structure

To give a more complete overview of the design thinking startups environment an analysis of the organizational structure of the ventures has been performed. The Matrix XX shows the relation between the number of employees and the total funding amount raised. Overall, the 27.6% (169) of the 612 ventures succeed to raise more than 5 million dollars. This means that the largest number of startups are still in the first financing rounds. In fact, there are 38.5% between 0 and 1 million and 33.8% between 1 and 5 million dollars.

Figure 6 : Funding/employee matrix of the design thinking startups

It could be interesting analyse the evolution of the organizational structure over the years to understand how design thinking startups prefer to organize themselves. The structure is as follows:

- 37.4% of the startups have 10 or less employees;
- 85.3% have a number of employees between 1 and 50;
- 14.4% with 50 or more employees;

There could be two main hypotheses behind the fact that most of the startups are composed of 50 or less employees:

(i) Design thinking startups are not mature enough to increase the organizational structure;
(ii) Design thinking startups better perform with a limited group of people.

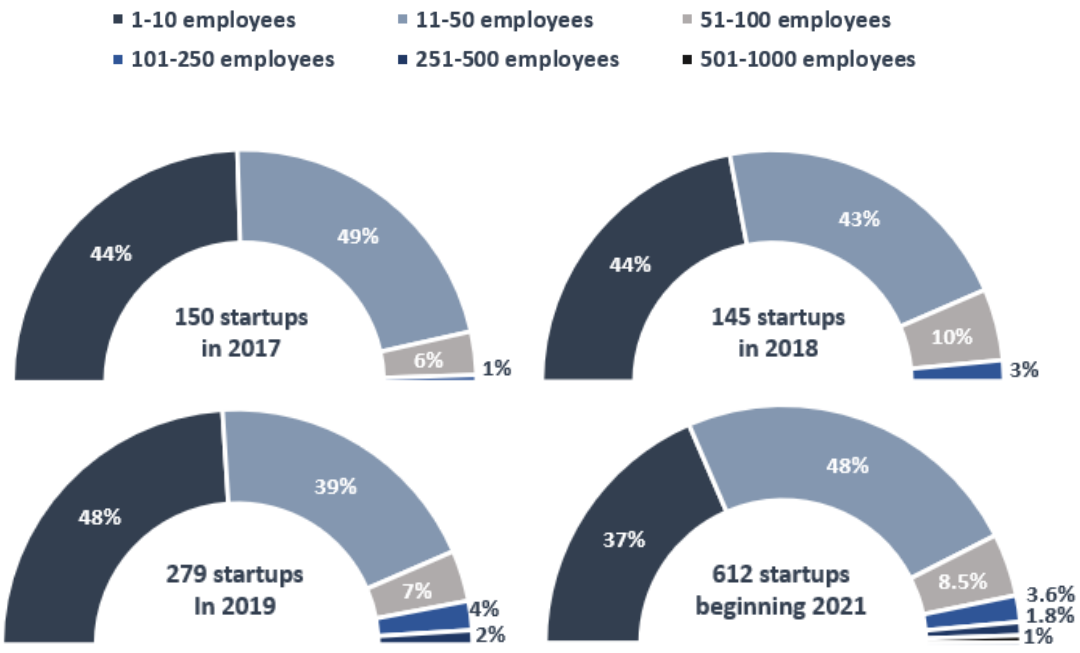

Figure 7 : Evolution of the employees of the design thinking startup

As it possible to notice from the Fig 7, it seems that the first hypothesis is the most correct. In fact, it is possible to see a positive trend regarding the number of employees per each startup. Particularly the threshold of 500 employees is overcome and for the first time there are ventures with an organizational structure with a team between 501-1000 people. Form 2019 results:

- The ventures with 11-50 employees increase from 109 to 293 (+169%) at the start of 2021;
- The ventures with 51-100 employees increase from 20 to 52 (+160%) at the start of 2021;
- The ventures with 101-250 employees increase from 11 to 22 (+100%) at the start of 2021;
- The ventures with 251-500 employees increase from 5 to 11 (+120%) at the start of 2021;
- The presence of 5 new ventures with 501-1000 employees at the start of 2021;

In every category the number is at least doubled, these results confirm the diffusion of the design thinking practices and the establishment of larger and more affirmed realities.

3.1.3. Design thinking approaches

As argued in paragraph 1.1.6., a further analysis has been performed regarding the four approaches to design thinking. The four approaches are distributed as follows:

- 42% (255 over 612) are related to the creative problem-solving approach;
- 41% (252 over 612) are related to creative confidence approach;
- 13% (80 over 612) are related to sprint execution approach;
- 4% (25 over 612) are related to innovation of meaning approach.

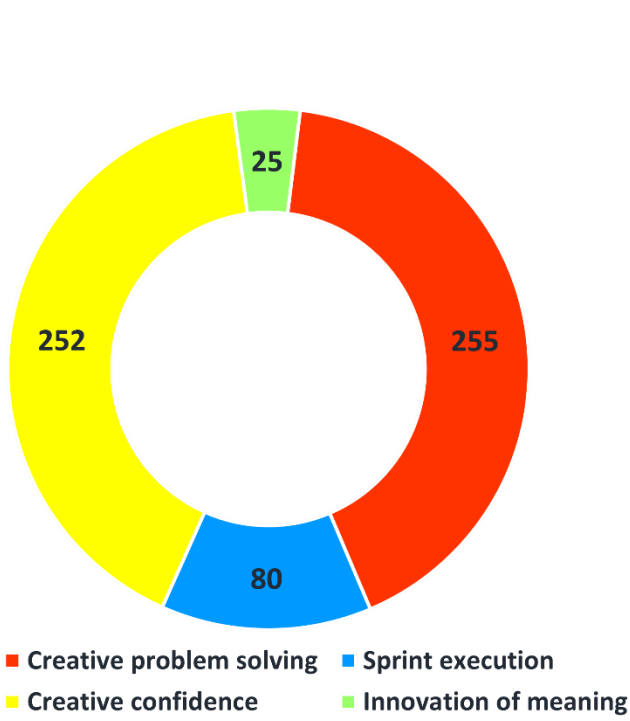

Figure 8 : Distribution of startups on the four design thinking approaches

As it is possible to notice in the Fig 8 there is a dominant position of two categories: creative problem-solving and creative confidence. The first one historically is the approach through which design thinking are born, so it is not a surprise find this approach as a dominant one. These startups are more focused on emphasizing with customer needs and ideating discover new opportunities. It is interesting such a strong presence of creative confidence approach, meaning that more and more startups are focused on making the employees confident about the innovation process, allow them to create engagement and co-desing. It could be supposed that the pandemic situation boosts this approach, having the necessity of work remotely allow a faster adoption of digital alternatives where collaboration is facilitated. Instead, the other two approaches have a significant gap from the first two. At the third position with 13% of ventures there is the sprint execution approach, which aims to deliver in the fastest possible way a product coherent with the users' needs. At the end of the ranking there is innovation of meaning, this suggest that design thinking startups are not predominantly focused on find a new 'why' of the offer of the firms.

The overall number of startups of each approach is not enough to correctly describe the environment. A further analysis related to the overall funding raised per approach and the correspondent average funding per ventures. The results are as follows:

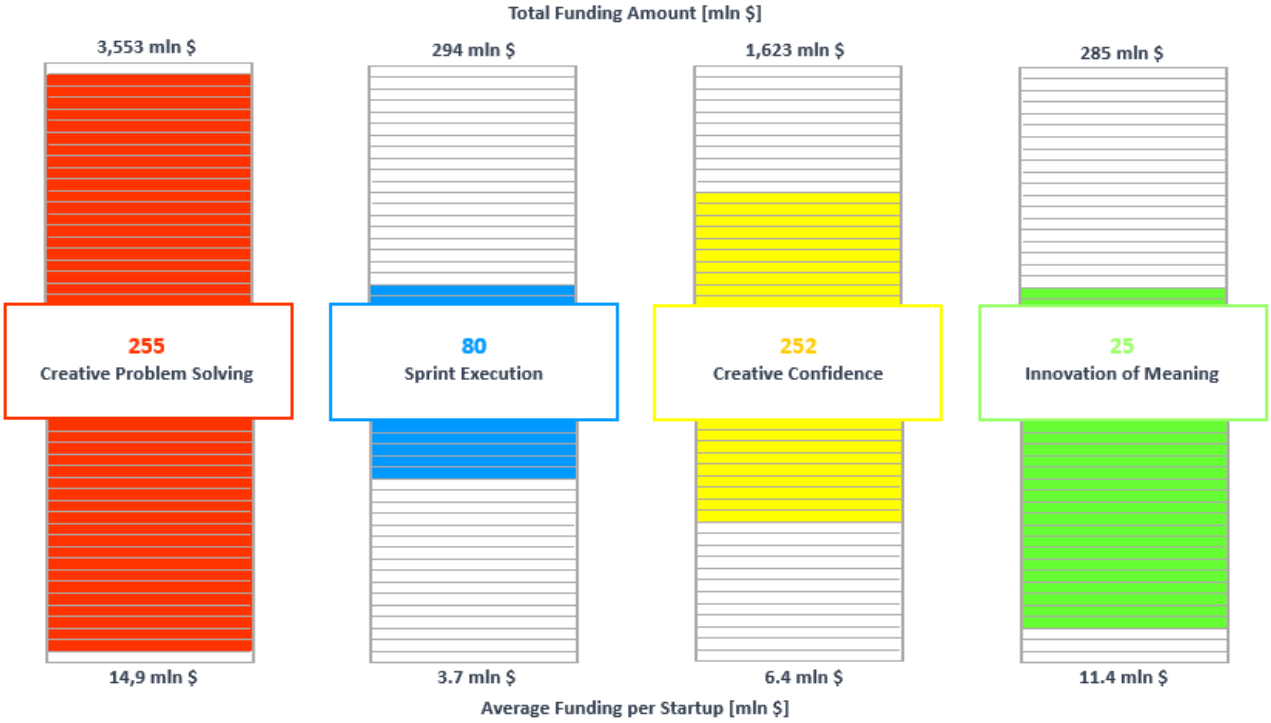

Figure 9 : Funding per design thinking startup

Creative problem-solving approaches received most of the funding, 82% of the total funds and each startup succeeds to collect almost 15 million dollars on average, confirming a dominant position of this approach over the others. The second highest amount of funds has been received by the startups focalized on the creative confidence approach which received 1,623 million dollars. Despite being the second category of the ranking based on the overall amount this category is third in average funds per venture with 6.44 million dollars. Surprisingly the second highest value of average funds gather by startups is the one of the companies which support the innovation of meaning approach. Meaning that despite these realities are not very diffused they are very well perceived by investors. At the end of both categories are positioned the startups which are focused on sprint execution approach.

As mentioned above, there are some companies which are more mature from an organizational perspective. The next step is about understanding the relationship between design thinking approaches and organizational structure of the ventures, to see if some approaches are more mature than the others. In Fig 10 it is possible to observe the outcome:

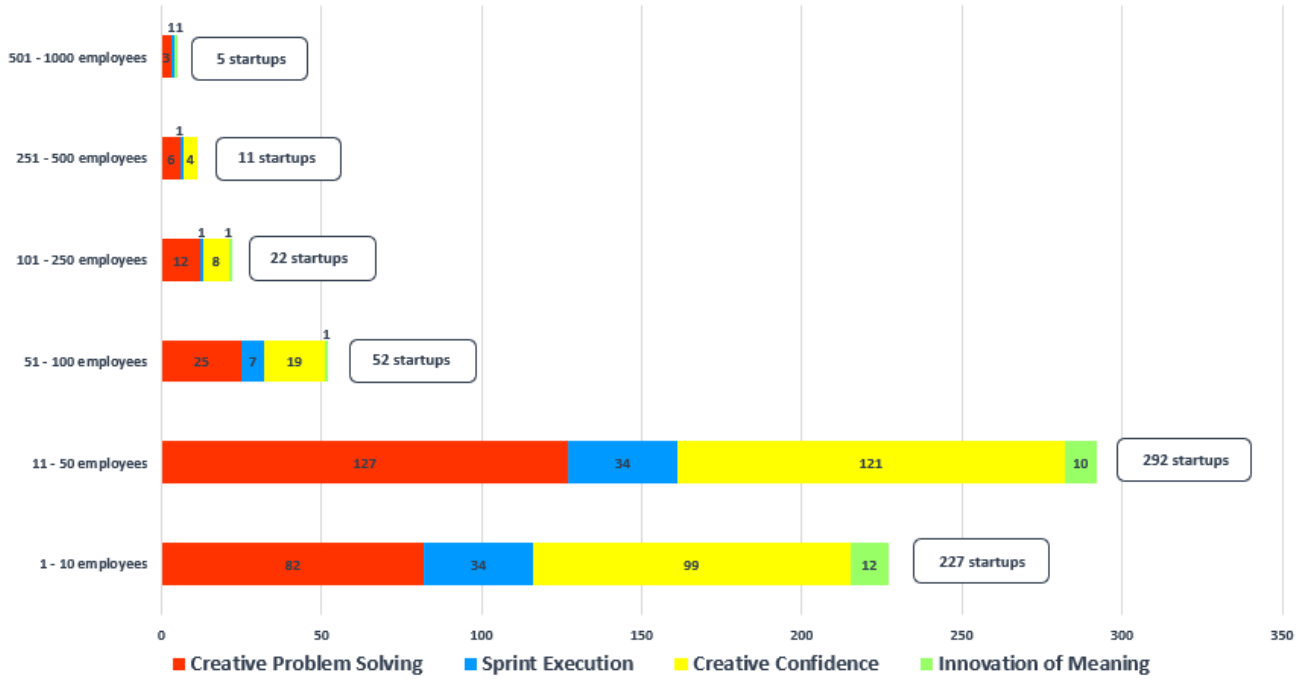

Figure 10 : Distribution of the sample subdivided by the various design thinking approaches

From the results, on one hand the creative problem-solving and the creative confidence have an almost regular presence in each cluster. On the other hand, as regards the sprint execution approach, it emerges that the 85% of ventures (68 over 80) operate with a team composed of less than 50 people. This happen for innovation of meaning startups as well, in fact there is a predominant presence (88% with 22 over 25) in the cluster with less than 50 employees. This could be interpreted as the willingness of these startups to operate with small teams or as the fact that these ventures are in the first stages and aim in a future consolidation of their position.

3.1.4. Metaphases supported by startups

The following analysis aims at illustrating the design thinking startups' scenario related to the design thinking metaphases. The phases should be the main steps by any design thinking projects and they are considered common to each of the four approaches. The analysis wants to discover if there are metaphases more considered by the investors and if each of the design thinking approaches are more linked to some step. The metaphases are described in the XX paragraph, they are synthesized as follows:

1. *Sensing and emphasizing*: the goal is to create empathy with the users in order to better understand the context of analysis;
2. *Interpreting and framing*: make sense of the insight gained during the previous step by set and frame the problem;
3. *Team building and task management*: creation of heterogeneous teams to have different point of view and opinions and guarantee open-mindedness;
4. *Ideating and conceiving*: try to solve the problem with creativity and the following generation of new ideas;
5. *Collaborating and co-designing*: each member of the group helps in developing in detail the new concept generated;
6. *Prototyping and learning*: a rough version of the concept is physically realized to allow an interaction with the users and obtain feedback;
7. *Launching and measuring*: beta solution are provided to market or user labs where first reaction and KPIS are monitored;

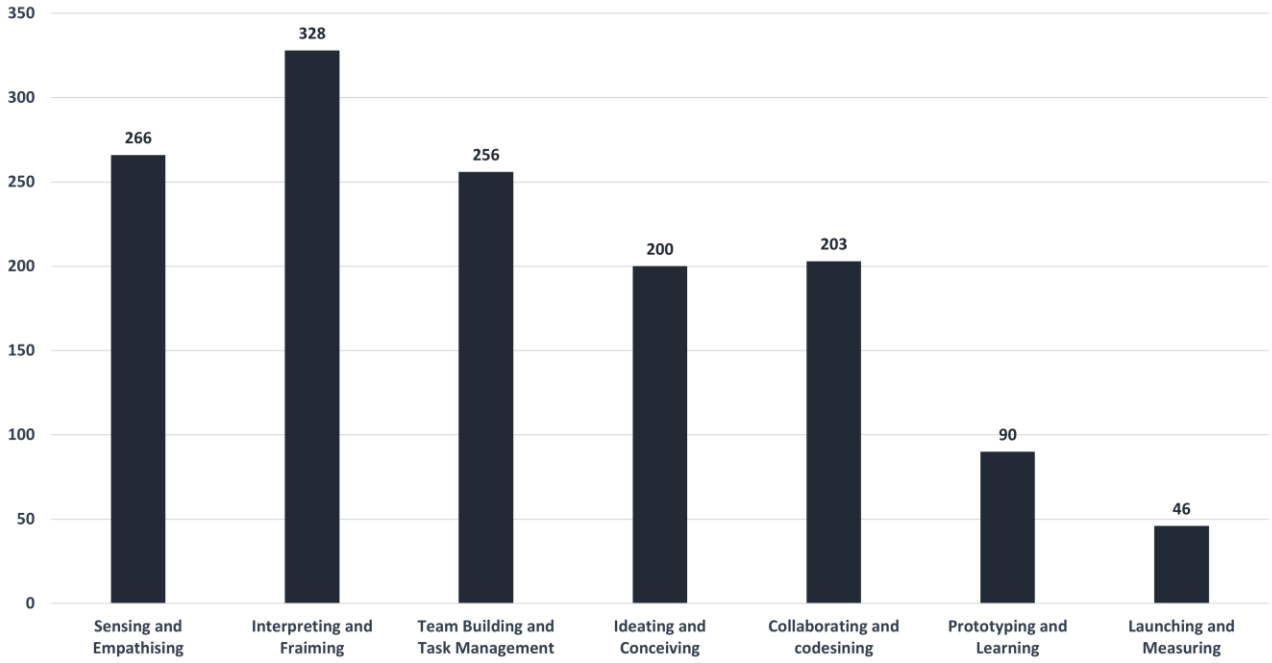

Figure 11 : Distribution of startups on the various design thinking metaphases

It emerges that the leading categories are the one in the early stages of the design thinking process. In fact, 'interpreting and framing', 'sensing and empathizing' and 'team building and task management' are the largest groups showing a focus of the digital startups in understanding and framing the problem and successively give instrument to form the right team which operates with useful tools. It is interesting to notice that the last two metaphases are the one on which the digital startups are less focused; showing a quite weak sustain to the 'prototyping and learning' and 'launching and measuring' steps. It is possible to assert that in this moment a restrict number of ventures are working on help companies to build fast their prototypes and learning from them.

The next analysis investigates the relation between design thinking approaches and design thinking metaphases. The results are in the following graph:

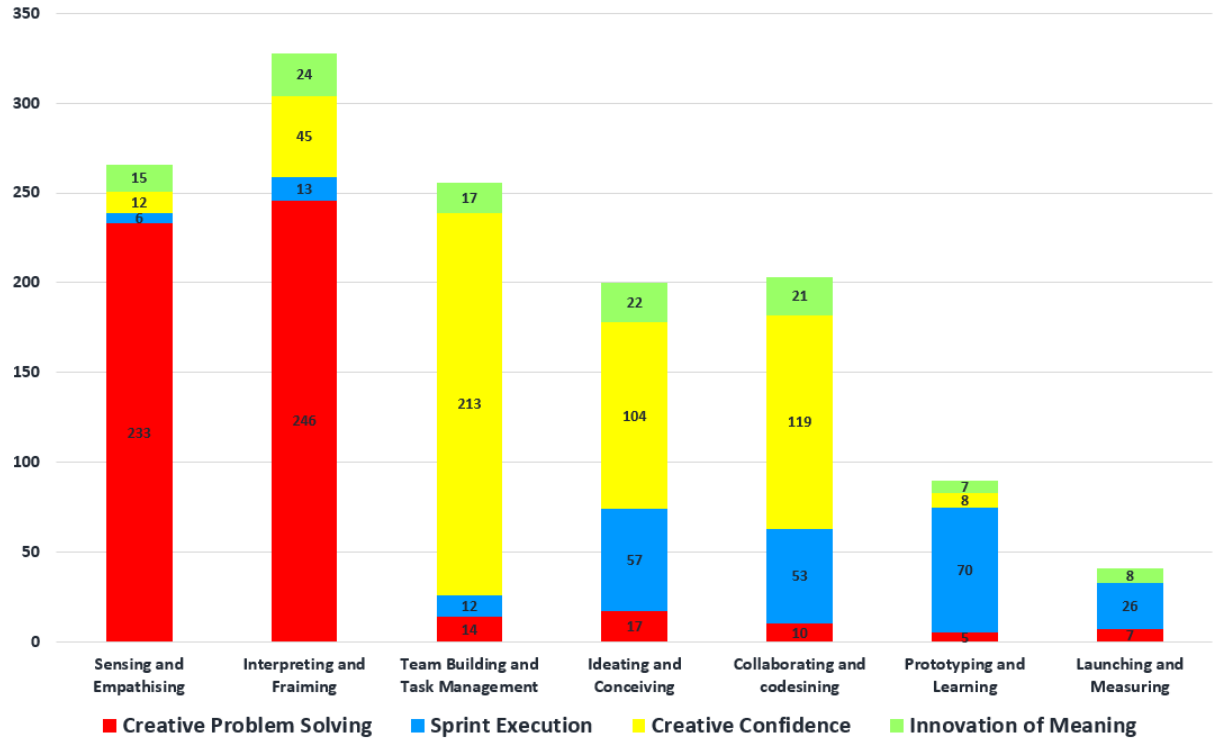

Figure 12 : Distribution of startups on the various design thinking metaphases and approaches

- 'Sensing and empathizing' and 'interpretating and framing' metaphases it is possible to see a dominant presence of the creative problem-solving approach, this clearly shows a strong relationship between the first two step and the mentioned above approach;
- In the three steps in the middle 'team building and task management', 'ideating and conceiving' and 'collaborating and co-design' the most present approach is the creative confidence one. It is possible to notice a strong relationship for instance in activities such as team formation and or in the use of tools which makes the employees more confident about innovation;
- The presence of startups which operates with sprint execution approach are more present in the last four metaphases, in 'prototyping and launching' and in 'launching and measuring' this approach is the dominant one. This approach is focused on deliver a ready-to-go product on the market; thus, it is in line with these concepts the main presence of this approach in the last two steps of the design thinking process;
- As regards the innovation of meaning approach it is possible to say that the presence is quite constant over all the metaphases. This is in line with the

mission of these digital startups, in fact they aim at creating a 'new why' with a radical innovation process;

3.1.5. Technological families

Talking about digital startups it is of absolute interest analyse which technologies are used to sustain design thinking project. This is very useful in order to understand which technologies are most suitable for enhance the design thinking practice and its metaphases. Has been identified five technological families which as an impact on the design thinking startups environment: artificial intelligence (AI), internet of things (IoT), cloud computing, big data and augmented reality (AR). Overall, just 189 over 612 digital startups do not leverage these technologies, meaning that the 70% of the startups leverage on at least one of the families. As it possible to notice from the Fig 13 the environment is almost dominated by the artificial intelligence, indeed the 92% of the service provided by digital startups (which use at least one of the five technologies) are based on AI.

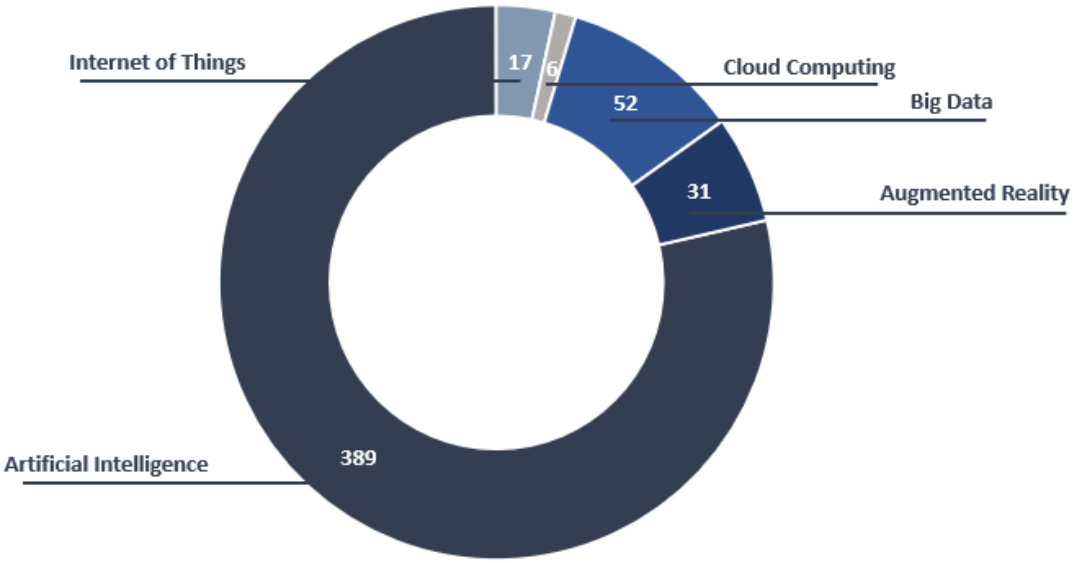

Figure 13 : Startups per technological families

The next step of the analysis aims at understanding how the investors perceive these technologies, to reach this goal the total found collected per group and the average found per startup has been analysed. In the Fig 14 it is possible to see the result:

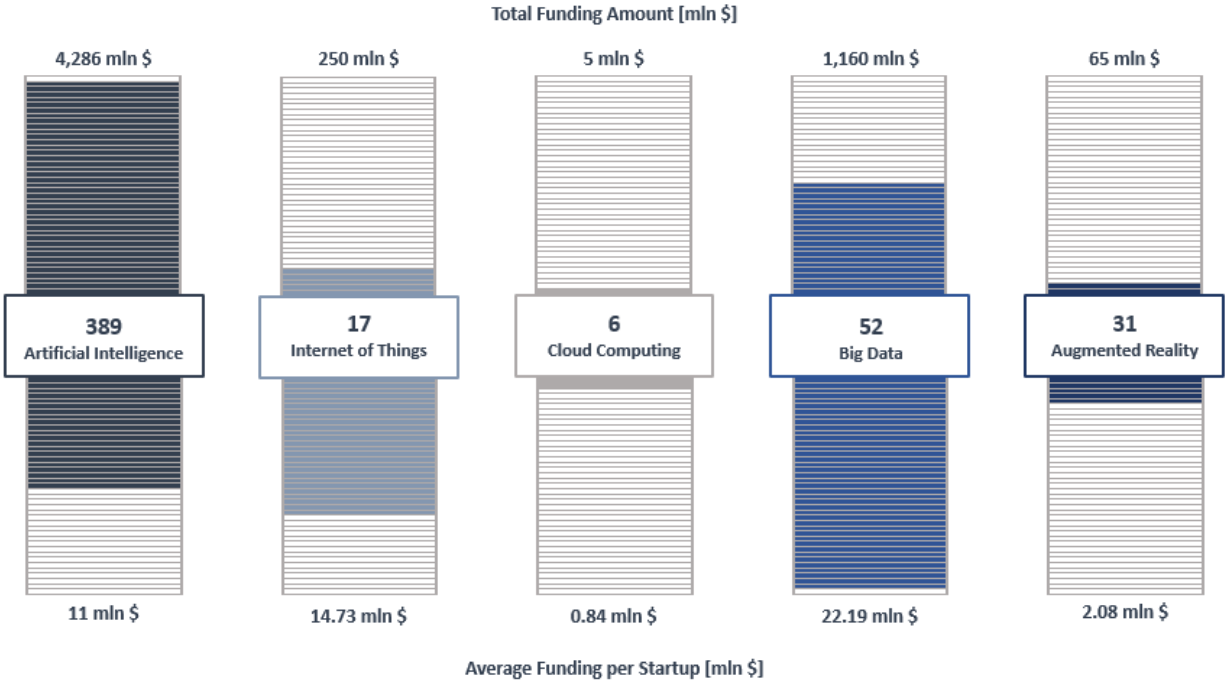

Figure 14 : Funding per technological family

Clearly the scenario regarding the total amount raised by digital ventures is dominated by the AI group. At this level of analysis, it is more interesting focusing on the average collected by each startups. In this case the main group it is the big data one which raises on average almost the double of the amount collected by the artificial intelligence group (22 million against 11 million), then it follows the second group, the IoT one, with an average of 14.7 million dollars. These two groups although they are composed by a restricted number of ventures (52 and 17 respectively) compared to the artificial intelligence one, seems to receive a lot of interest by investors. The group which seems to have more difficulties is the cloud computing one with the lowest value by far both for the total funds received and for the average fund per startup.

The next step of the analysis has the goal of understanding on which metaphases the technological families are more utilized. The result is as follows:

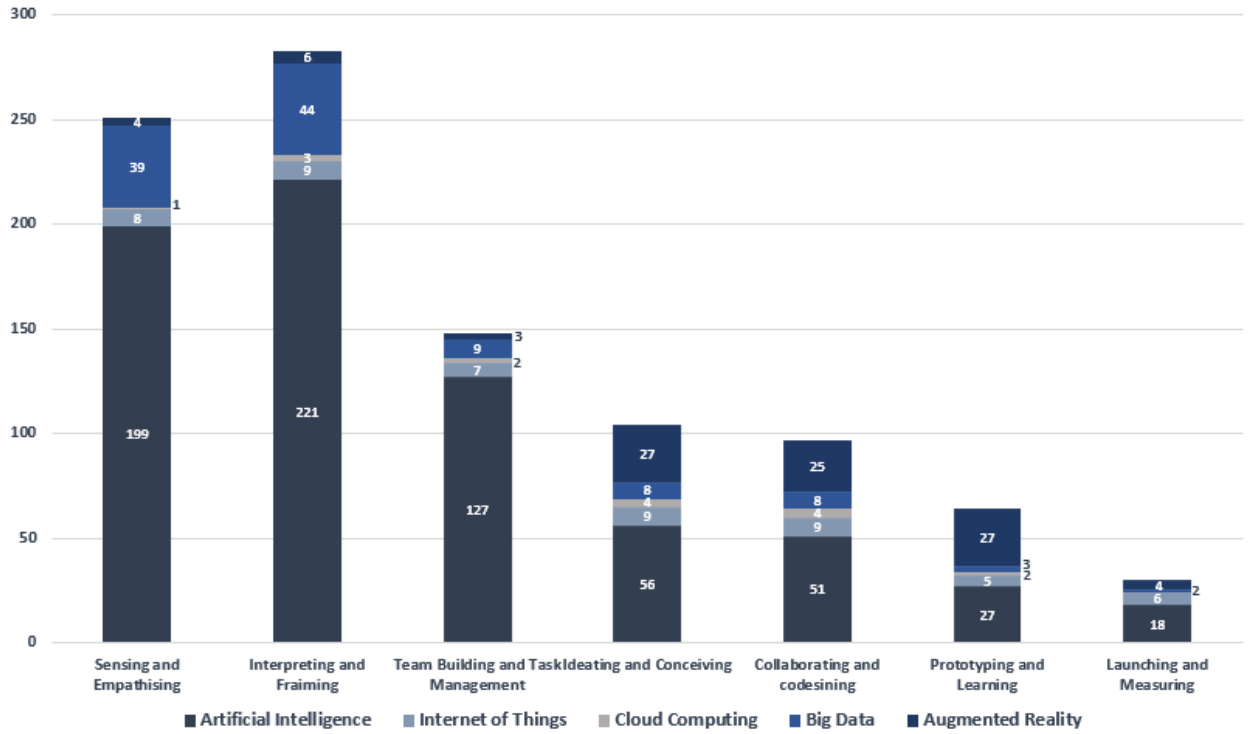

Figure 15 : Distribution of the technological startups on the various design thinking metaphases

- In the first two metaphases 'sensing and emphasizing' and 'interpreting and framing' the two major families are artificial intelligence and big data. This is absolutely reasonable the two families are the most suitable for the two steps. In fact, one hand big data helps companies to make sense of the huge amount of data, gather insights and frame the problem. On the other hand, artificial intelligence is really useful to create empathy with the users understanding their emotions and analysing their usage pattern during the experience.
- Regarding augmented reality it is reasonably more present in 'ideating and conceiving', 'collaborating and codesigning' and 'prototyping and learning' phases. In fact, AR allows to enhance creativity and to fast create prototypes with low investments. Many of these digital ventures propose some virtual reality services as well, which results useful in remote collaboration in room where everything is possible also against the physics law.

It is easy to notice how technologies are more focused on the first steps of design thinking practices, in fact there is a clear descending trend. Nowadays digital technologies can effectively sustain the first part of the metaphases, specifically the step which aims at making sense, understanding and framing the problem. Regarding the second part which is focused on the creation of the solution and its launching, digital technologies are not yet at the same level of efficiency. However, this result does not to be daunting regarding the future opportunities; in fact, the digital technologies have all the necessary characteristics to give strength to the second part of the design thinking process.

The last part of the analysis related to digital technologies investigates the relationship between technology families and the design thinking approaches. The results are illustrated in the following graph:

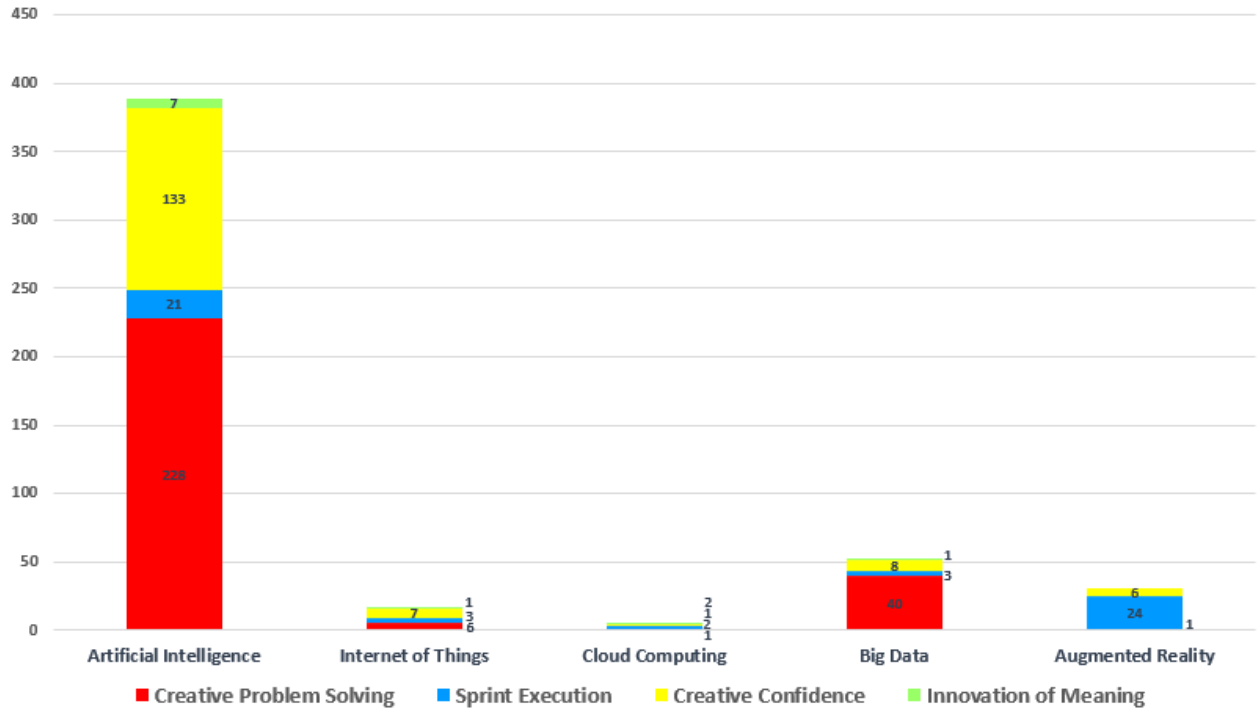

Figure 16 : Distribution of the technological startups on the design thinking approaches

Looking at the graph it is possible to state:

- Artificial intelligence is predominantly related to creative problem-solving and creative confidence approaches. This is reasonable considering the

peculiarity of these technology. For instance, in extract precious insight from conversation between users and chatbot, regarding creative confidence approach, or helping team formation, regarding the creative confidence approaches;

- Big data are reasonably more focused on creative problem-solving approach, confirming that it is a technology which operates with data in order to make sense of tons of information, gather insights and frame the problem;
- Augmented reality is prevalent related to sprint execution approach thanks to its peculiarities, indeed it allows to create fast prototypes and enhance creativity.

3.1.6. Business model adopted by startups

To conclude the analysis of the digital startup ecosystem related to design thinking, an analysis of the business model adopted by startups has been performed. This to understand how ventures can scale up, grasp value from the market and replicate in the long range. The point of reference is the pricing strategies adopted by the ventures and present on their websites. The five primary methodologies identified are as follows:

- *Fixed Price*: a single price related to the product/service;
- *Versioning*: a range of price, each one referred to different versions of product/service offered;
- *Demo*: an opportunity to try the product for free for a limited time horizon;
- *Freemium*: the basic version of the product is for free, if the users want a different version the prices are shown;
- *Quote by email*: there are not information related to price or different versions of the offer. To have this information it is necessary to contact the sales department;

The results are as follows:

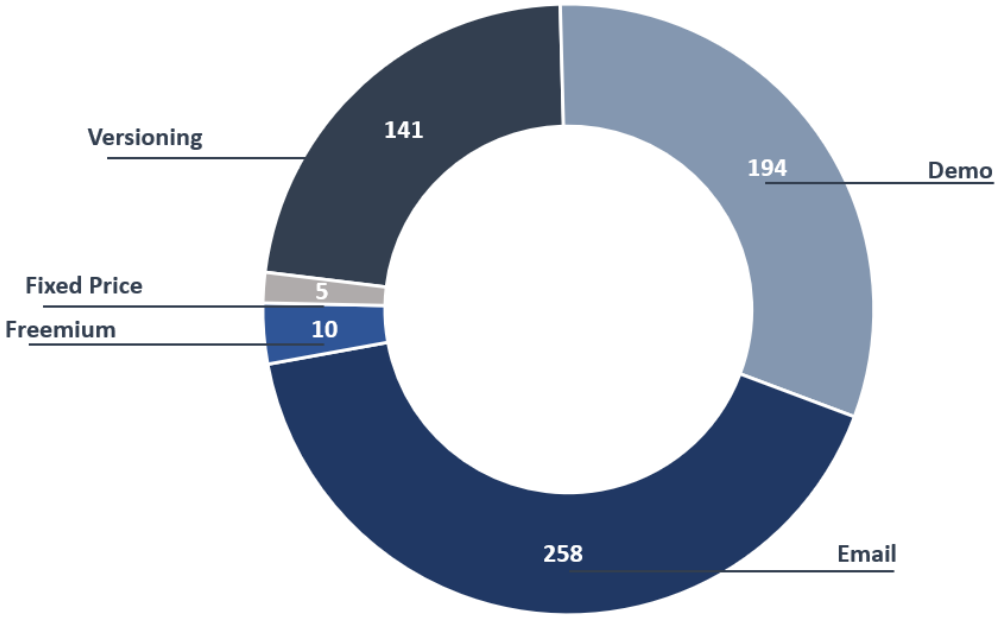

Figure 17 : Distribution of startups on the five pricing strategy

- 'Quote by email' has the highest percentage: 42% with 258 startups over a total of 612. This modality is probably strategy to interact with potential clients in order to better understand their needs. This allows to avoid the fact that the visitors which is potential interest leave the website without contact the companies once they have seen the prices;
- 'Demo' strategy shows interesting numbers with 32% (194 out 612). In this case, startups decide to let the users try the product for free and test it for a limited period. This is probably a preferred way to obtain a 'locked in' effect over the users and receive more accurate feedback;
- With 23% of preference (141 out 612), at the second place, there is the 'Versioning' strategy. This revenue model for startups is useful in order to maximize the subscription trying to satisfy the maximum number of users. The 'Versioning' model is very similar to the 'Freemium' one where the basic version has a free rate. The latter model is not very present with just 10 startups which adopt it;
- At the end of the ranking with the lowest number is the 'Fixed price' model with just 5 startups. This probably shows how this revenue model is no longer utilized in dynamical context such as the one of digital startups.

Indeed, in this environment a competitive advantage can be the flexibility in terms of offer to the final user and with this revenue strategy it is not feasible.

Then has been performed an analysis about the total funds raised and the average funds per startups of each revenue model cluster.

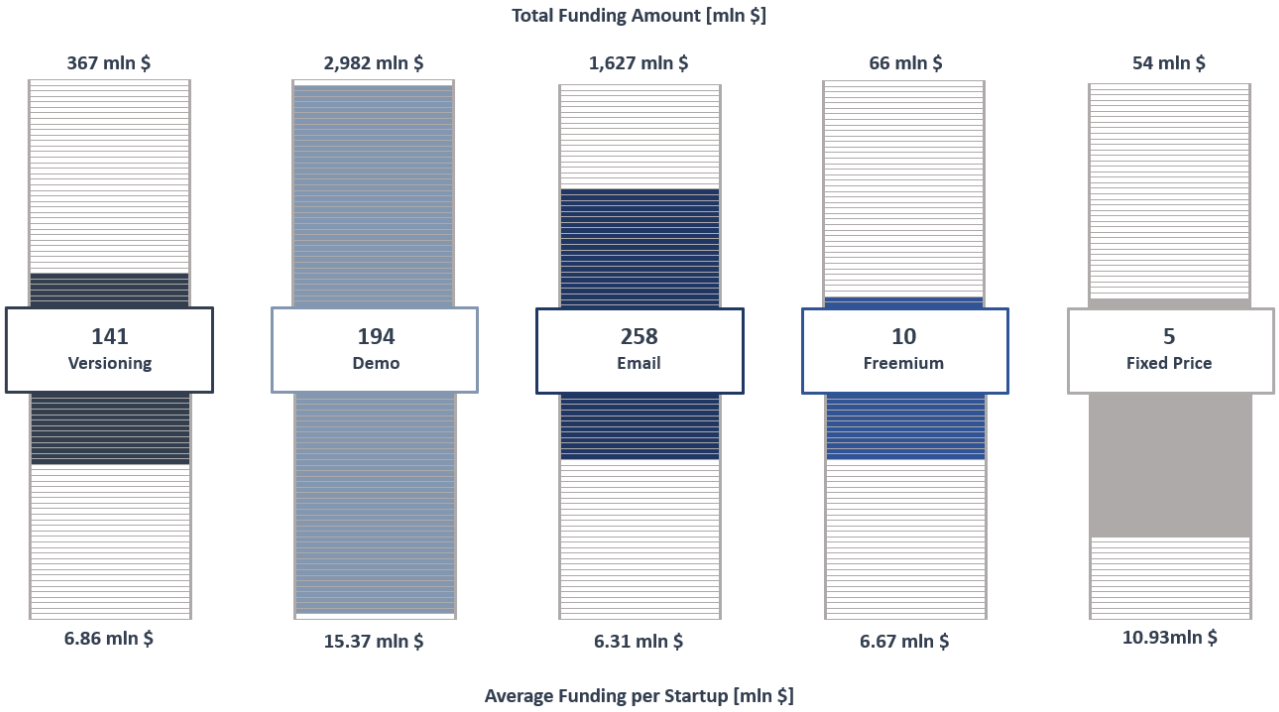

Figure 18 : Funding per pricing strategy

From the Fig 18, the best result is achieved by the startups which offer a demo as an initial trial. This is probably perceived as a competitive advantage by the investors because it is a signal that the startup is willing to shows the benefit of their offer and confident that the users will buy the product/service after the trial. It follows the startups which adopt a revenue model among 'versioning', 'quote by email' or 'freemium' revenue model with an average funds raised between 6 and 7 million dollars. Regarding the 'fixed price' strategy, the result is very good with an average of almost 11 million dollars per startups. However, the result based on a sample of just 5 startups it is biased by the presence of a ventures which succeeded to collect more than 37 million dollars. Thus, it is possible to state that the market perceives the 'demo' revenue model as the best among all and this allows the startups which adopt this staregy to differentiate themselves.

3.2. Multiple business case analysis

3.2.1. The role of AI in the understanding of the problem

In design thinking practices a lot of effort is in the first part of the innovation process, the deep understanding of the problem. Traditionally in this phase humans use their capabilities to frame and reframe the problem with a focus on the customers' needs. AI can support the first part of design thinking practices thanks to its ability to analyse huge amount of data in a fast way and identify different patterns. The major of the interviewers highlight this characteristic of AI:

> *"We're helping organizations enable AI models which run very rapidly and quickly. Especially when you're dealing with massive, massive amounts of data and hundreds of terabytes of data, that's where really we come in."*
>
> *(S6 GM)*

Moreover, with the AI it is possible to gather data from different sources such as documents or images. This is possible thanks to the different capabilities of AI such as the understanding of the content of documents through IDP (intelligent document processing) or NLP (natural language processing) or also by using cameras and analysing the images collected.

> *"Through IDP, Intelligent Document Processing, based on machine learning and semantic analysis we can extract information from documents and elaborate them."*
>
> *(S1 CMO)*

And

> *"It is possible to summarize document automatically using NLP natural language processing algorithm. We do summarization pulling out information."*
>
> *(S7 CTO)*

And

> *"We base our computer vision projects on 2D camera because you get a better angle and better perspective of gathering data."*
>
> *(S5 CPO)*

These capabilities allow to quickly collect huge amount of data from different sources and analyse them at a pace before unthinkable. This is done in order to quickly grasp insights and information and create new knowledge by identifying new patterns in data. Thanks to the new information is possible to better define the problem which the design thinking practice aims to solve by emphasizing more with the customer base by better understanding their needs.

> *"Our product is specifically for business intelligence purpose where it helps the customers get information from their data."*
>
> *(S8 CEO)*

And

> *"They are currently using out product to analyse their current customer base and then be able to identify different segments. Just being able to segment out your audience or your customer base and then be able to identify persona groups and understand what they need."*
>
> *(S6 GM)*

And

> *"Maybe going into reviews and understanding whether it was positive or negative. Identifying what are the problems people have with products from some of those reviews. For example, in social media data like what are people tweeting about a product."*
>
> *(S6 GM)*

And

> *"The key thing about having valuable insights of their customers it's the ability to better emphasize with them."*
>
> *(S5 CPO)*

The benefits of adopting AI technologies do not finish here, indeed, thanks to its ability of understanding language through NLP it can answer to questions in normal languages. This makes allows a democratization of technologies, in fact it is easier for people with no technical skills to reach the insights elaborated by the algorithm and to access to the new information.

> *"NLP has allowed to build a conversation interface which helps humans communicate with machines. It can be connected to any source of data that can be any database or spreadsheet or anything. Once you connect that to data you can ask any questions in normal language, but only restricted to whatever is there in the data."*
>
> *(S8 CEO)*

It the emerges the ability of AI to analyse and makes sense of data which comes from different sources such as images, document, social media and so on. This represent a big advantage considering that these activities were previously done by human or less sophisticated software; advantages in terms of time and costs saving, discover of new insights and the limited impact of biases over the results. It is possible summarize all this evidence in the first preposition:

- **Proposition 1**: *AI allows to better understand the problem and deeply emphasize with customers by facilitating the analysis of large amount of data from different sources and generating insights which human can access in an easy way.*

3.2.2. The impact of AI on the ideation phase

The capability of AI to analyse huge quantities of data, discover new patterns and connection of different topics can be used to manage knowledge inside organizations and provide new insights. This could be useful during the ideation phase in design thinking processes. For example, the service provided by S7 allow to discover new insights by analysing different articles and topics and generate new knowledge inside the companies:

> *"It is possible create knowledge base from articles and document where there are connections between different topics in order to gain new insights."*
>
> *(S7 CTO)*

This allows companies to generate new knowledge and understand what is going on in the world; it could be useful during the abduction reasoning in the ideation phase by giving new insights which can lead to new thoughts and ideas.

"This can help companies trying to stay on the edge of innovation and one of the ways to do it is just maintaining that knowledge and keep growing that knowledge."

(S7 CTO)

Another example is represented by S1 which has developed a software which help companies to discover new insights useful during the ideation phase. They offer a solution able to analyse many documents containing information about past project and so provide new insights about what worked in the past and what did not work.

"I would not say it will help to innovate, but at least they can design something new based on past experience."

(S1 CMO)

And

"AI can investigate a huge data set for and extract something you may use or not. Then with past experience and past knowledge it is possible to sustain intuition, creation and design"

(S1 CMO)

Another way to use it is by providing document regarding new patents. In this way it is possible which are the new ideas around, which are adopted by competitors, which works, and which not.

"It tries to measure every time a new idea is generated, and it can be like an alert system which detect patterns and measure the adoption of these new ideas in the communities."

(S1 CMO)

And

"They need to pay attention to idea which start to become popular in order to be in the right track and not bypassing any new solution or letting a new solution to their competitors."

(S1 CMO)

Another big advantage related to the capability of AI is the opportunities to explore different options. Once the constrains are set in the algorithm different output are generated and this can lead to the evaluation of different options by humans. This happens in the service provided by S4 in which the objective is not find the

minimum of an equation rather explore different options considering different factors.

> *"AI is not just good to find the minimum of a certain function, but also at exploring different options try to combine different factor and find interesting output that maybe they are not the best one according to the objective function, but it doesn't matter because the objective function doesn't represent the reality 100% anyway. It is more about visualizing the trade-off."*
>
> *(S4 CSO)*

In this sense AI allows to use a holistic approach considering factors which belong to different fields:

> *"The benefit of AI is that it can take this more holistic approach where it will explore the different factors and it will give options that can sometimes push the design in different directions."*
>
> *(S4 CSO)*

And

> *"The environmental, social and political impact are different factors that an algorithm could potentially considers during the designing phase."*
>
> *(S4 CSO)*

By doing this, AI allows to exit from existing mental pattern and explore new things by reducing cognitive biases. Anyway, what really matters is not the data in se but rather how that data can stimulate human capabilities.

> *"Data is just data and there is no value just in data analysis. The importance of it is in the action or the outcome of it. So, involving people and utilizing the data to stimulate creativity and intuition."*
>
> *(S5 CPO)*

And

> *"You fall into patterns and into sort of certain way of doing things and you're used to looking at things from a really specific perspective. AI can give you a new perspective or confirm what you already thought."*
>
> *(S4 CSO)*

In general, it is possible to assert that the service based on AI can be thought as a virtual assistant which can answer to your questions and provide you new insights. Moreover, thanks to the opportunity to communicate in a natural way with the algorithm it is possible access to the new insights without having strong analytical skills.

> *"We are thinking about something new, and we have also the software that can sustain us with some insight like a virtual assistant."*
>
> *(S1 CMO)*

And

> *"The key thing is that the users do not have to rely on anyone else to get the information that they need from their data. They don't need to have any analytical skills."*
>
> *(S8 CEO)*

AI could also be a support in the brainstorming, during the understanding of the problem and the ideation of a solution phases. S3 works on this concept by providing a tool which tries to structure an ideation process by automating the brainstorm phase. Once the problem is defined the AI software-based thanks to its capability will structure the problem solving reaching the new solutions.

> *"Once you have a topic area in which working on, we will help you to break it down, understand what you don't know about it and then do the background learning to get up to speed."*
>
> *(S3 CEO)*

And

> *"During the ideation phase you have expand and contract cycles. You brainstorm, and then you narrow. I think like we're trying to essentially automate that and document it. So, during brainstorms, we automatically collect a list for you."*
>
> *(S3 CEO)*

The software is based on the possibility to understand the level of knowledge of the team members, this is done by recording and understanding the questions of the people inside the group during the brainstorm. The tool will categorize the different

level of knowledge by understanding the scale, specificity and the value of the questions related to the end goal.

> *"We do a lot of brainstorms where people will put in a lot of questions they have about a topic, for example, and the first use of AI is just to categorize all that information and make it much faster for someone who's reviewing it to see overall what's going on in the course."*
>
> *(S3 CEO)*

And

> *"It is based on an idea called inquiry-based learning and the idea of inquiry-based learning is that the most effective in natural way to learn about a new topic is to first define your goal."*
>
> *(S3 CEO)*

And

> *"It is making easier understand what is going on so beginning to score the value of different contributions. So, if you have people doing a brainstorm, which ideas are going to be or which questions are going to be most valuable to solve the problem."*
>
> *(S3 CEO)*

The software work on iterative cycles, in each cycle it records the discussion and understand the level of understanding of the problem; then it tries to assign different tasks to each group member to prepare them for the next brainstorm and increase the level of knowledge.

> *"They can use that essentially to say: "ok, what did we understand about this problem and where are meaning gaps?" So, concretely what we're doing is we're giving them a set of tasks and a collaboration platform for iteratively solving complex problems."*
>
> *(S3 CEO)*

By doing this the software structures the process and reinforce collaboration to reach innovative ideas. Moreover, it is possible to understand the different contributions during the ideation phase by avoiding biases in the evaluation of skills which are difficult to measure.

"We give at every individual in the company a process they can follow in order to work on a new concept and so the best thing we do is give everyone a process."

(S3 CEO)

And

"AI can normalize score relative to different contributions avoiding biases and guarantee that everyone is being scored on the same system."

(S3 CEO)

And

"The goal is essentially measure skills not possible to measure otherwise. So, any skill you cannot measure on a multiple-choice test is very very hard to measure consistently because you every person that you have giving score on those skills would score differently."

(S3 CEO)

And

"I think we can train a system to judge how valuable a proposed idea is in reference to a goal and that alone I think would be very helpful."

(S3 CEO)

The algorithm can tag different topics and understand how they are related by creating a mind map which shows all the connection created by the group during the brainstorms.

"So, we can require people to brainstorm questions, and then to identify which one they're gonna answer and then to submit and share in a public space how they answered it and what information they learned. And then we take all that information, and we build it into a mind map automatically."

(S3 CEO)

And

> *"With the tool it is possible distil all the knowledge process into a diagram that illustrates the understanding of the systems. Moreover, the diagram can show how different factors are connected and which ones are influencing each other."*
>
> *(S3 CEO)*

Ideally by doing this it is possible to understand the structure followed to reach the solution and so in some sense mapping all the ideation phase. By collect enough data of this kind of information AI can be potentially become a recommendation system and suggest questions on tasks to perform to speed the grasping of new knowledge by each team member and quickly elaborate the new solution.

> *"So, we actually have a path of how someone got to an answer. I think that data is going to be incredibly valuable because if you have a sufficiently smart system to analyze it, then you can start making predictions about which ideas are most valuable for which problems because you can essentially say, well, people were in a similar scenario when they thought about that thing."*
>
> *(S3 CEO)*

And

> *"AI could use the information to be potentially more predictive and suggest related topic in to develop more knowledge."*
>
> *(S3 CEO)*

And

> *"I think that one of the really powerful long-term benefits of AI is actually being a recommendation engine for how to go about solving a problem. AI can actually say: "no no, I know you like this question, but trust me, this other question is actually going to be way better and give you way more interesting information to help you to solve your problem faster"."*
>
> *(S3 CEO)*

Considering all the above-mentioned information it is possible to assert that AI can definitely sustain the ideation phase thanks to its capabilities to provide new insights about what is going on in the world or about past project performed by the companies. This can help the team to understand which are the most valuable ideas to pursue, what works and what does not work and also discover some new information which can support the abductive reasoning. Moreover, AI can sustain

the brainstorming by assigning different tasks to each member of the innovation team and by understanding the level of comprehension of the group. In general, it is possible to say that AI is a useful instrument to manage the level of knowledge inside the companies, to develop more information and to evaluate the different contributions of all the people who compose the group. All the evidence are summarized in the following proposition.

- **Proposition 2**: *AI can sustain the ideation phase helping the creation of knowledge, the discovery of new insights and the brainstorming activities which can enhance the stimulation of new ideas.*

3.2.3. Managing feedback and fast-test through AI

The ability of services based on AI of capture and fast analysing large amount of data can become useful also in the last part of the design thinking process. In particular, in the part in which the innovation team launch the prototype and learn from the early feedback of the users. AI can be useful in this sense in many ways, for example thanks to its capability to make sense from data it is possible analyse information regarding the feedback of the customers in order to grasp insights and refine the product.

> *"If you want get information around something you can use our tool where you can set up and say: "Ok this is what I want to know", connect the right data and the product can give you the answers. If the information is about the feedback of your customers, you can ask about them."*
>
> *(S8 CEO)*

And

> *"Clients can use this product to understand the feedback that they get from their own customers. So, if the data, the input data are feedback, you can analyze the feedback and then decide what they need to do to implement that feedback. So, we can help with the analysis of the feedback that they get."*
>
> *(S8 CEO)*

AI thanks to its capability of analysing image data can be useful to find new insights from the physical experimentations. An example is provided by the S5 which is able to analyse the images captured by 2D cameras and provide new insights. Referring to experimentations the interviewee refers to concept closed to design thinking practices.

> *"Then it is important iterate as fast as possible, experiment as broadly as possible, engage as many people as possible to gather information about what works and what doesn't work."*
>
> *(S5 CPO)*

And

> *"The results of the experiment should be stored and combined with all the intelligence in the rest of the ecosystem, consultants, suppliers, analysis ecc.. This would produce a lot of creativity"*
>
> *(S5 CPO)*

Then it is important store this data in order to improving the understanding of customers and enhance the empathy; this leads to a better knowledge inside the organizations and the opportunity to refine the solution.

> *"All the data which comes from experiments needs to be stored so that everyone understands what has been done and what should be done next."*
>
> *(S5 CPO)*

And

> *"They need tools to store all the experiments and all the data that comes out from the experiments in order to keep learning."*
>
> *(S5 CPO)*

And

> *"The higher level of experimentation you can do the better the results you're gonna get because it's all based on data and the actual users."*
>
> *(S5 CPO)*

AI is also able to understand where the attention of the customers goes when they look at a certain design. This is possible by training the algorithm with a lot of data. Many designs could be tested such as a new packaging, a new web page, a new app, media or also the shelves in the shops.

> *"This artificial intelligent could be implemented so that for example could use for UX and UI designers to test designs before they launch anything on the web."*
>
> *(S2 CMO)*

This allows to have a result by just uploading the document on the tool and then AI will elaborate the heat map which indicate where the attention goes.

> *"The predictive eye tracking allows to just upload a document and get the prediction."*
>
> *(S2 CMO)*

AI understands different designs, but the difficulties is in set the right model according to the different tests you want to perform.

> *"You can create different model according to the different design you want test."*
>
> *(S2 CMO)*

This is done in order to speed the test phase which allows to refine the solutions. Indeed, this kind of testing is faster and with lower costs, considering the no involvement in the eye tracking research which usually is a long approach.

> *"AI would not help in design faster but to help them to solve a design issue before they launch anything."*
>
> *(S2 CMO)*

And

> *"Our solution challenges the market because we understand where the attention of people goes, we have data, and we can improve the solution every year. So why we need users to organize the research of the eye tracking and have a so long approach."*
>
> *(S2 CMO)*

By considering all these different capabilities of AI can be considering a support during the collection of the feedback and the understanding of the latter. Indeed, the capability of AI of discover new patterns and produce new insights is useful in

order to generate value from feedbacks by deeply understanding their meaning. Moreover, AI is starting to replace humans in some tasks especially by automating repetitive actions and by performing them with more accuracy in the results. This allows organizations to refine the solution according to the real customers' needs and preferences by saving time and costs. The following proposition summarize all this evidence.

- **Proposition 3**: *AI allows to fast test the design and refine the solutions thanks to its ability to capture and analyze large quantities of data and improve the comprehension of the feedback.*

3.2.4. Synergies between AI and human

All the AI solutions are based on the opportunity for machine of replicate capabilities typical of human beings. Capabilities such as listen and understand the meaning or recognize what is present in a certain image. Starting from this concept it follows the ability of human in performing the same activities which the AI software performs.

> *"If you look at a video or if you would stand in a store, you could observe that actions yourself. It wouldn't be difficult to understand if somebody is entering a store or is passing products or stopping by products."*
>
> *(S5 CPO)*

So, AI aims at replicating human actions and, moreover, perform them in a more efficient and effective way. Indeed, the main advantage that the adoption AI gives is the opportunity to manage large volume at a higher pace; this leads to a substitution of the human thanks to the automation on some activities that are simple and repetitive and consequently an increasing in accuracy and in cost saving.

> *"The solutions allow to reduce the cost of data capture because instead of mobilizing human resources they will mobilize some CPU and GPU which are less expensive than human"*
>
> *(S5 CPO)*

And

"I think a lot of work which is very simple, repetitive, mundane kind of work will get replaced by machines. So, anything that does not require too much of thinking, and it's just repetitive king of work will get done by machine only."

(S8 CEO)

And

"They can do it at scale means that if they need to extract data from 10,000 documents it's fine. If they need to extract from 10 million of documents is doable. It's a matter of selecting the right server considering that most of AI are fully scalable on the cloud."

(S1 CMO)

Once the algorithm is set, it is able to work and manage information on really large scale. This ability to replicate many times simple tasks gives benefits in terms of time and cost. Consequently, it is possible to do more and elaborate more data in order to gain valuable insights and develop knowledge.

"They are not thinking but they are really good at pattern recognition on really large scale."

(S7 CTO)

And

"Cost savings implies that you can do more and because you can do more at a lower cost you will get more information to consider in the decision process."

(S1 CMO)

And

"The value is saving you time and it also create this knowledge base that you can explore and fine new insights."

(S7 CTO)

Considering all this benefits and the opportunity to communicate with the algorithm with NLP, the services based on AI can become a sort of virtual assistant which provide you valuable insights during your innovation process.

"You can build the system where you can ask a question in the natural language and with the knowledge extract from documents."

(S1 CMO)

And

"It's like having an assistant which answer to all your questions and facilitates the understanding of data."

(S8 CEO)

And

"The tool can help you to expand your knowledge faster and more broadly and in a way which feels more like a game."

(S7 CTO)

And

"We are very much going for the sort of synergy approach of the AI is more like a co-pilot."

(S4 CSO)

The virtual assistant becomes an entity which enhance human capabilities by giving new insights in the right moment which can support the ideation of something new or the understanding of the customer needs.

"It's an aide to humans to help them work faster, smarter, better. It is not going to replace people. It's not really going to create new insights. But we're gonna help a human find them more quickly."

(S7 CTO)

And

"Our solution wants to help human to better understand data in a way that they cannot do alone."

(S8 CEO)

In this sense, a competition between human and AI does not exist rather the main advantage comes from the creation of synergies between the two.

"It doesn't make sense to try establish a competition between human intelligence and artificial intelligence."

(S1 CMO)

And

"The real advantage Is combining AI with human skills."

(S8 CEO)

And

"AI will not replace the engineer but rather will give the engineer more information so they can make more."

(S4 CSO)

And

"Meet up with humans and how we can add humans to do their job better."

(S7 CTO)

In this way, AI augments the capabilities of humans by give the valuable information in the right moment and allowing to develop the knowledge in a fast way with less effort.

"We have to make artificial intelligence as a tool to develop the capability of the humans, so to do some tasks at which they are not so good, so you might have not so good to do like the repetition like working at scale."

(S1 CMO)

And

"It makes it easier to see what is going on. You don't have to dive in deep, so it saves time. It helps you read more, learn more and make connection between different topics."

(S7 CTO)

Then, the human takes decision based on the data provided by AI with more accuracy and a less exposure to risks.

> *"You can have some predictions but is important that the person make the decision on the base of the number provided."*
>
> *(S8 CEO)*

And

> *"In order to solve the problem, the best way is to make sure that the humans have the right amount of input and insights into what happening."*
>
> *(S6 GM)*

And

> *"The main advantage is that now it possible to base decision on data derived from their past experience which arrived from legacy report. They can take advantage of all the success and errors did in the past. This would reduce the exposure to risk."*
>
> *(S1 CMO)*

It is clear how AI and humans can collaborate side by side trying to improve what the other is not good at. In fact, AI is really good at repetition and pattern identification with the generation of insights while the human is capable of work on those insights and ideate and create something new. In this sense AI must automate the weak skills of humans while augment their strong skills. The synergies among the two can lead to superior performance during the innovation process, by reducing the costs, the risk and saving time. Considering the above mentioned it is possible to state the following proposition:

- **Proposition 4**: *To maximize the effectiveness of the adoption of AI in design thinking process and reach superior performance, AI must automate the difficult tasks for humans while augmenting and enhance human capabilities.*

3.2.5. Trust in the output of the algorithm

It is clear that an integration among AI technology and humans' capabilities is the right approach to reach superior performances. Humans take the insights which are the output of the algorithm and develop new ideas and reasoning on this new information. Considering that many organizations rely this service on other companies, like it happens in this study where digital startups support the processes

of other companies, it becomes crucial that the end users trust the output of the algorithm and understand which are the logic behind a certain insight. This because, otherwise, AI is not able to be effective in the support of the customer's processes such as the design thinking one.

> *"This the model we build must be built by the business expert because when you create when you extract data automatically from documents. At the end of the day. The user must trust the data."*
>
> *(S1 CMO)*

This problem is due to the characteristics of AI which sometimes is seen just like a black box in which the internal dynamics of the algorithm are not clear. An example is provided by the machines which use deep learning algorithms that use unknown logics to reach the output. The result is that often the end user must be reassured regarding the accuracy of the results, because many times he/she does not trust them.

> *"How could somebody trust data which has been extracted by a black box?"*
>
> *(S1 CMO)*

And

> *"Engineers are not going to trust a system that just sort of from A to B does everything because they're not going to know how it arrived at this conclusion."*
>
> *(S4 CSO)*

And

> *"And you cannot have a system which is a work by itself more or less automatically and expects that somebody will adopt it. We don't think so."*
>
> *(S1 CMO)*

And

> *"It's very difficult to force somebody out of the domain of AI to understand why we have to take this information and not this one."*
>
> *(S5 CPO)*

And

> *"Artificial intelligence is like black box because, for example I haven't technical competences and I can't explain how the artificial intelligence works. We can say that it's the black box. But the point is that clients want to be sure if it's a good black box or bad black box."*
>
> *(S2 CMO)*

To solve this issue companies are trying to gain certifications which assert a certain level of reliability; but they have to do more because at the end of the day is the clients who must use and really trust the output of their algorithm. In order to do that the solution is in the integration between human and machine. Indeed, the end users must be involved in the loop and the digital startup must explain them why a choice is done instead of another and why the algorithm produce a certain output rather than another one.

> *"How did you come to the conclusion that this was the best approach is really difficult because you have a sort of black box AI system that just spits out something. So, definitely very much in the synergy and sort of working together side for this type of problem."*
>
> *(S4 CSO)*

And

> *"We need trustable data, and we consider that the human has to be in the loop."*
>
> *(S1 CMO)*

It is clear how the theme of trust is essential in to have an effective support of the AI in the end user's processes. Indeed, AI can have all the kind of capabilities but if the digital startups are not capable to be clear and fully explain the process behind the results, the integration will be unsuccessful. So, they must put a lot of effort in involving their customers in their processes to be fully transparent about the logic and the processes. With this kind of involvement there will be a win-win situation: on one hand the digital startup can improve the reliability of its algorithm while on the other hand the end user can successfully utilize the AI model inside his/her organization. The following proposition summarize the above-mentioned concept.

- **Proposition 5**: *It is important involve the end user and explain how AI elaborate the final output and why humans should work on it; this in order to build trust in the results and increase their reliability.*

3.2.6. Summary of the multi case analysis

The previous paragraphs present a detailed study of the cases regarding how digital startups can support design thinking practices. First, an understanding of how AI can be useful in the first part of the process, particularly the understanding and the framework of the problem. This is possible thanks to the capabilities to capture and analyse huge data sets and produce insights after having identifies patterns. By doing this, the algorithms allow to create empathy with customers by better understanding their needs (Proposition 1). Consequently, it is showed how AI can be a support during the ideation phase in particular by providing useful insights related to different topics, by structuring brainstorming and by managing knowledge inside organizations. All these AI's capabilities support the stimulation of new ideas which lead to the generation of new solutions (Proposition 2). Moreover, AI can be used to support the iterative part of the process characteristic of design thinking. Indeed, it allows to better understand experimentations by capturing and analysing data and to understand where the attention of users goes on different design (Proposition 3). The characteristics of AI cover the pain points in the human skills such as the repetitive actions or the recognition of patterns in large datasets. In this sense, it is possible to create synergies by automating these kinds of activities with AI and, successively, with the outputs of the algorithms augmented human capabilities (Proposition 4). All of this is possible only if humans trust the result of the algorithms and, considering that AI models are seeing as black box, digital startups must involve their users in order to explain the actions of the machine (Proposition 5).

The following table summarize the results.

Proposition	Main highlights
Proposition 1: *AI allows to better understand the problem and deeply emphasizes with customers by facilitating the analysis of large amount of data from different sources and generating insights which human can access in an easy way.*	The capability of AI allows to identify patterns in the data and better understanding the customers' needs in order to framing the problem in the best way.
	Thanks to the interfaces based on AI especially NPL, it is possible to easily access to these insights and facilitates the comprehension of the users' needs.
Proposition 2: *AI can sustain the ideation phase helping the creation of knowledge, the discovery of new insights and the brainstorming activities which can enhance the stimulation of new ideas.*	The insights generated by the analysis of AI algorithms can be provided to the innovation team during the ideation phase and stimulate new ideas.
	AI can support the brainstorming phase by structure the ideation process splitting it in questions and tasks for the team. The algorithm leads to the new solution.
Proposition 3: *AI allows to fast test the design and refine the solutions thanks to its ability to capture and analyze large quantities of data and improve the comprehension of the feedback.*	AI allows to speed the test phase by analysing the feedback of customers or the results of physical experimentations.
	AI models can replace the human by giving feedback is a fast and less expensive way. However, it does not always have the same accuracy in the results.
Proposition 4: *To maximize the effectiveness of the adoption of AI in design thinking process and to reach superior performance, AI must automate the difficult tasks for humans while augmenting and enhance human capabilities.*	AI can give benefit in terms of costs and time thanks to its scalability. It can replace humans in repetitive and analytical activities.
	The output of AI can augment the human capabilities by enhancing creativity and intuition. This will result in more ideas and innovation.
Proposition 5: *It is important involve the end user and explain how AI elaborate the final output and why humans should work on that output in order to build trust in the results and increase their reliability.*	The digital startups must involve the end users in the loop in order to build trust in the output generated by the algorithm.
	The involvement of the users allows to obtain feedback on the result which will lead to an improvement of the digital startup service.

Table 5 : Summary of the proposition and their main highlights

4 Discussion and Conclusion

In this chapter the theoretical and empirical implications which derived from the result illustrated in the previous chapter are discussed.

4.1. Discussion

This work wants to approach the theme of design thinking from a different point of view than the usual one. Indeed, the thesis aims at understanding how startups, in particular the one of which service relies on digital technologies, can support design thinking practices. The first part of the results describes the structure of the ecosystem of digital startups from which emerges a prevalence of adoption of AI technologies. From that point the work moved to a field still not fully explored, how artificial intelligence could effectively support design thinking processes. In order to answer to this question a multiple case analysis was performed which led to the identification of five main propositions. The following paragraphs take up the two research questions that guided the analyses carried out. In each of them the main results achieved will be summarized by connecting where it is possible with theoretical references. The discussion aims to illustrates how the results of this research can bring value to the existing theory.

4.1.1. Mapping the design thinking startups ecosystem

The ecosystem of startups which can support design thinking practices is growing constantly over the years. This is confirmed by the fact that in less than two years the number of startups related to this innovation process is more than doubled; indeed, there were 279 startups in 2019 and 612 at the beginning of 2021. Together with the expansions of the ecosystem also the interest of investors is increased reaching an overall amount of funding of 5.8 billion dollars from the 2.1 billion dollars of the 2019. This is not only due to the increasing of the number of companies in the sample, indeed, on average, each startup succeeds to attract more funds as it is shown by the average collected per startup which is increased by almost two million dollars reaching an average of 9.5 million dollars. This can be seen as an opportunity to create new organizations, indeed entrepreneurs increasingly seen in

the design thinking the right field where to develop their business ideas (Suroso et al., 2017). It is possible notice the increasing attention in this subject also considering the geographical dispersion of these startups. In fact, design thinking is spreading all over the world demonstrating to not be a trend which belong just to the USA. Despite being predominantly present in North America with 283 startups also Europe and Asia start to have a large representation with respectively 183 and 117 startups. Moreover, it is interesting to see how some case of digital startups related to design thinking practices starts to emerge also in continent less developed such as South America (10) or Africa (4). Considering that in 2015 the funds were located for the majority in the North American and European markets, the situation changed in 2016 when there were some investments in the Asian market, followed by its consolidation in 2019. In 2021 it is possible to consider the Asian market as the European one, and both are covering the gap with the North America. Considering this trend, one possibility is to have a balanced situation among these three continents; followed by the other three which are constantly increasing over the years: from 2019 to the beginning of 2021 Oceania +200%, South America +150% and Africa +33%. These numbers seem to confirm what is stated in the academic paper regarding design thinking: an ever-expanding phenomenon which gain more attention over the years (Micheli et al., 2019). The maturity of the ecosystem is confirmed by an increasing consolidation of the organizational structure which compose these startups. The average number of employees per startups constantly increase and for the first time the threshold of 500 employees is overcome. To deeply understand how design thinking ecosystem is structured, a further analysis regarding the design thinking approaches was performed. What emerged is a balanced situation between creative problem-solving and creative confidence, showing a major adoption of these two approaches. In particular, the startups which are focused on the creative problem-solving approach succeeds to attract more investment both on the total and on average. This represent in some way an evolution of the adoption of design thinking practices which traditionally was focused just on the creative problem-solving approach. Indeed, nowadays it is possible to assert that this approach is used like the creative confidence one; meaning that companies are more interested in using design thinking to shape the organizational culture towards an innovative approach. One hypothesis is that the raising interest in the creative confidence approach could be due to the pandemic situation; in fact, having the need to work remotely could have boost the adoption

of digital solutions which facilitate the collaboration in teams. In the third position is present the sprint execution approach while at the bottom there is the innovation of meaning one. The latter, despite the presence of just 25 startups, succeeds to be the second in the ranking based on the average of funds collected, meaning that although these realities are not very diffused, they are very well perceived by investors. Regarding the metaphases the majority of startups provide services/product which are focused on the first and the second part of the design thinking process, so the deep understanding of the problem and the collaboration of the innovation team in order to find a new solution. The last part of the process in which a prototype is launched to perform tests and learn from early feedback shows low numbers in term of startups and consequently a weak support of the 'prototyping and learning' and 'launching and measuring' metaphases. A further step is done in order to understand which of the most innovative technologies are more suitable to effectively sustain design thinking practices. The adoption is massive: indeed 70% of the startups have a service or a product which relies on at least one of the following innovative technologies: artificial intelligence (AI), internet of things (IoT), cloud computing, big data and augmented reality (AR). Among these technologies AI is the one which results dominant in the adoption; indeed, the 92% of the digital startups which rely on at least on technological families have an offer based on AI. Considering the high volume of digital startups which relies on AI, the overall amount of funds is clearly polarized towards this technology. However, the situation is different in terms of average funds collected per venture; indeed, considering this, big data and internet of things are the two categories with the higher value. This shows a high consideration for these two technologies by investors, despite a limited number of startups which rely on them compared to the AI ones. Regarding AI it is possible to asserts, considering its dominant presence in the sample, that it is equally present in each one of the seven metaphases. Particularly, AI combined with big data almost completely support the first two metaphases; this is completely reasonable considering the ability of AI in extract information from big data in order to generate insights for the company. Indeed, AI helps in making sense from large amount of data in a way that humans find difficult to handle (Cautela et al., 2019). Moreover, solution such as chatbots which relies on natural language processing allows to better emphasize with the customer base. Another interesting aspect is the adoption of the augmented reality in the 'ideating and conceiving', 'collaborating and codesigning' and 'prototyping

and learning'. Indeed, this technology is often proposed with the virtual realties, two technologies which leave freedom to experiment and create almost everything imaginable (Ondrejka, 2007; Kohler, 2009). Moreover, thanks to the development of the hardware in the recent years, it is possible to collaborate through avatar in these virtual worlds. Overall, it is possible to notice that the technologies are used more in the first part of the design thinking process, during the understanding of the problem, and then its support gradually reduce. According to Cautela et al. (2019), in particular regarding the adoption of AI, the technology will support humans in the "context of the (design) problem" allowing to focus the attentions to the "context of the solution". This is possible thanks to the abilities of digital technologies of accelerating the researching phase, connecting data from different sources and identifying in a fast way patterns. However, the technologies start to support the last metaphases of the design thinking process. This is possible, for instance, thanks to the development of virtual and augmented realities as above mentioned or thanks to the 3D printing technologies that allow to fast create prototypes which allows to test hypothesis. AI can have a strong impact also in this phase with its capabilities of providing new insights which can stimulate new ideas. This indicates a possible strong contribution from different technologies to the design thinking practices, allowing to support humans during the innovation process and consequently obtain more reliable winning solutions with less effort. Furthermore, considering that the ecosystem is composed by startups, it has been performed an analysis of the business model adopted by these ventures. Particularly, the focus of the analysis was on the pricing strategy of the startups. Most of the stratups adopt a 'quote by email' pricing strategy, showing a willingness to interact directly with the potential customers to deeply understand their needs and to create a relationship. However, considering the total funding amount and the average funding amount per startup, the dominant cluster is the 'demo' one. This means that investors perceive as more valuable and mature companies which are willing to show directly to potential customer their offer and its benefits.

4.1.2. The support of AI to design thinking processes

The multiple business case analysis has produced relevant insights that are useful to understand which role AI could interpret in order to support design thinking practices. From the interviews it is clear how AI can help during the first part of the design thinking problem; namely 'sensing and emphasizing' and 'interpreting and framing' metaphases. Indeed, it is a peculiarity of design thinking put a lot of effort during the understanding and the definition of the problem. The design thinking practices aims at deeply emphasize with the end users in order to understands their needs and solve wicked problems. In this sense, AI can play an important role during these metaphases. One of reason is the ability of AI models in managing huge amount of data from different sources and this allows to gain more valuable insights and better empathizing with the end users. Indeed, as emerged from the interviews, AI models can analyse data from different sources such as images captured by cameras in a mall or reviews of a certain product on social media and produce new information. In this sense, the use of artificial intelligence in analysing these different kinds of data allows to identify new patterns that emerged from the combination of data which comes from different touch points and, consequently, more valuable insights not biased by humans (Cautela et. al, 2019). It could represent a new era in which AI provides more objective analysis for the understanding of user, substituting activities which were considered for long time not accurate due to the subjectivity of inputs (Cautela et al., 2019). Moreover, AI allows to perform these activities at a higher pace and, due to the scalability of the models, with less costs which results in more information to humans. This leads to the automation of activities related to the understanding of the problem, which enables organization to reduce cost, faster processes and ensure a better level of rationality and consistency (Raisch, 2021). Considering these elements, it is possible to state that AI can fully support the first part of the design thinking process by automating activities which were previously performed by humans with less efficiency and effectiveness. This results in benefits for humans that are no more forced to do activities in which they have poor performances; and this could help to shift from monotonous and repetitive tasks to more creative and fulfilling ones (Raisch, 2021). Indeed, once set the algorithm, it performs autonomously the analysis and provides new information to humans who will base their decisions on these insights. Furthermore, this is facilitated by the capabilities of the AI algorithms

in understanding the natural language; indeed, humans can ask directly to the algorithm questions in the natural language and the insights will be quickly provided. It results useful also in the consequent steps of the design thinking processes, the 'ideating and conceiving' one. Indeed, the opportunity to analyse huge data sets and receive as output valuable not biased insights at which it is possible to access in an easy way thanks to the Natural Language Processing (NLP) can be also used during the ideation of the new solutions step. In this sense, from the interview emerged the possibilities to analyse document written on paper on past projects, article related to different topics or new patent adopted in the market. This facilitates the generation of new knowledge inside the organization, at which is it possible to access with not effort a without having an overload of new information. Thus, the AI algorithm became a virtual assistant which can connecting dots of different topics and then provide the useful insights at the right moment to stimulate new ideas to humans during the abductive reasoning. AI helps innovators on not relying just on their experience, which is limited both in scale and in scope, by providing sophisticated insights which are shortcuts in abductive reasoning (Garubio, 2021). Indeed, according to the author, abductive reasoning is often generated by unusual and surprising observations which can be represented by the insights provided by the AI solution; moreover, from the quality of the observation derives the quality of the abductive hypothesis and consequently the quality of the new solution. Another advantage, which derives from the adoption of AI, is the opportunity to manage tasks during brainstorms and to help in structuring the new idea generation process. This is possible by recording conversation and rating the different contributions of the participants by analysing the questions asked during the brainstorm. Indeed, the analysis of the specificity, the value to the end goal and the scale of the questions performed by AI allows to understand the level of the understanding of the problem by the team. Then, by analysing these data, AI is capable of suggest different tasks, for instance research on a certain topic, to different team members who will share with the group the results of the individual activity during the following iteration. Moreover, by connecting the activities and the different topics discussed, the AI tool is able to create mind maps useful to understand the path which leads to the final solution. AI can be also valuable in offer different points of view by allowing to exit from the consolidate mental patterns of humans, indeed, the AI software can help humans during the design phase by considering different factors allowing to adopt a holistic

view and to suggest new directions to pursue. What is important is not in the data but how the data is used and how human reasons on that data to build new ideas; in this way AI could augment humans' capabilities by stimulating new thoughts and creativity. This augmentation during ideation phase combined with the automation of the understanding of the problem allows to reach additional benefit and enables the creation of synergies which consequently lead to superior performances and foster innovation (Raisch, 2021). Considering all these elements it is possible to assert that AI can effectively sustain the ideation phase during design thinking processes. Moreover, once AI solutions will be effectively used during the ideation process by organizations and enough data are collected, the AI could become a recommendation tool capable of providing valuable insights from unrelated topics or to suggest different paths to follow to generate new ideas. The potential of AI of imitating human minds is not able to replace the creative jobs (Cautela et al., 2019); however, its ability to make unusual connections makes AI effective in the ideation phase thanks to its support to humans. Furthermore, AI presents relevant benefits in the last phases of the design thinking process as well; the one related to the gather of feedbacks to refine the solution proposed. The first benefit is once again related to the capability of analyse large data sets which can be related to the feedback from customers or to empirical experimentations and the consequent analysis of images or videos in order to extract useful insights. Moreover, AI proposes innovative solutions in this field such as the predictive eye tracking which allows to identify were the attention of users goes on new design trough heat maps. This method could replace the usual test performed with humans that are usually long and expensive. The result is a quick test, which leads to a faster iteration and refinement of the new product, with the use of more accurate and less costly not biased insights. Overall, it is possible to assert that AI is capable to completely support the design thinking process resulting in a more accurate, less expensive and faster innovation process. However, there also limits in the implementation of AI in design thinking process. First, in many cases there is a lack of trust from the companies in the offer provided by the digital startups; indeed, often the end users see the AI as a black box from which an output is generated, but 'how' is generated is not clear. To solve this issue, it is important involve the end users and fully explain which factors are taken in consideration by the model. This can give benefit to both sides: on one hand, the end user can fully understand the output of the AI model and truly grasp the value added; on the other hand, digital

startups could better understand users' needs and improve their AI solution. Indeed, having the human in the loop to explain the outputs allows to have algorithmic decision more accurate and transparent (Raisch, 2021). Lastly, another strong limit is the lack of enough data to train the algorithm which limit the theoretical potential of the AI solutions making it difficult to perform some activities in practice. Moreover, another strong constrain is the limited use of well-structured innovation processes, like design thinking, inside organizations; indeed, it is difficult to for digital startups offer a tool which can make the design thinking process more effective and efficient if the end user does not follow a structured process to reach innovation.

4.2. Theoretical contributions

In this paragraph are highlighted the theoretical contributions to the existing literature of the insights which emerged from this research.

1. First, the multiple business case analysis with in-depth direct interviews allows to enrich the study of Cautela et al. (2019). From this analysis it is possible to confirm the impact of AI on the "context of the (design) problem" thanks to the analytical capabilities of the technology. It allows to shift the focus on the "context of the solution" where humans are not left alone, moreover, AI as a virtual assistant, which effectively communicates through NPL, can provide interesting insights to stimulate ideas or suggest tasks to develop knowledge. This allows to support the central part of the design thinking processes, the ideation phase, as well. Moreover, the empirical evidence seems to reinforce the statements of the authors about a future scenario in which AI will be able to autonomously test products and provide feedback like humans. Nowadays, it is not already completely possible, but technologies such as predictive eye tracking show a trend that goes in this direction. These models improve proportionally at their usage; indeed, the algorithm can learn from feedback and use the data to improve the accuracy and the reliability of the results; this could enable in a near future to have more effective solution in providing feedback and testing and allowing to cover also the last part of the design thinking process.

2. The evidence allows to reinforce the work of Raisch (2021) in which the author considers AI in managerial tasks in practice. Indeed, the author states that the integration of automation, so the replacement of human activities by machine, and the augmentation, meaning that human and machine work closely together, will lead to superior performances by firms and consequently foster innovation. This seems to be confirmed also in the design thinking realm by the results of the interviews in which both aspects emerged. On one hand, AI could replace humans in the first part of the design thinking process, allowing to have machines performing repetitive and monotonous tasks faster, with less costs and more reliability. On the other hand, virtual assistants based on AI can enhance human capabilities such as creativity and intuition providing right insights and so augmenting people skills. This integration allows to develop synergies which results in a faster and more effective design thinking process which allows organizations to reach innovation. Moreover, the author states that having the human involved in the algorithm's loop could help in explaining the output rendering the algorithmic decision more transparent. This is highlighted also in the results of the interviews, indeed, what emerged is that, to create trust in the output of AI, the user must be involved to really grasp the consideration behind the actions of the model. It allows to have tools more aligned with the customer's requests and end users which fully grasp the benefits related to AI, resulting beneficial both to digital startups and the end users.
3. Garubio (2021) studied the impact of AI on the generation of innovative ideas. Indeed, AI, with its capability of providing reliable insights related to different topics, can support the abductive reasoning. This emerged also from the analysis of the interviews: indeed, as previously mentioned, AI is effective in supporting idea generation during design thinking practices thanks to the capability of providing insights. The opportunity to extrapolate insights from different sources and manage the knowledge inside organization through AI gives the possibility to stimulate new thoughts upon which is it possible to structure the abductive hypothesis. From the interviews it is clear the opportunities to have insights which can provide different points of view for instance regarding the adoption of new patents in the world or the benefits of a new technology. This enlarges the knowledge

inside the organization and provide useful tips at which humans can access in an easy way. Also in this case the use of AI, as a virtual agents capable of providing new information, can represent a big advantage for companies which can develop new ideas at an higher pace.

4.3. Managerial implications

The results of this work want to provide useful information for managers and practitioners which want to better understand how digital startups could support design thinking practices and how to use artificial intelligence to support this innovation process. In particular, the insights result useful for both sides. On one hand, digital startups could understand how their offer can support design thinking, especially with the use of AI, because many times these ventures are not aware about this opportunity. On the other hand, organizations which decide to adopt the solutions provided by digital startups can understand how use them to support their innovation process. The managerial implications are as follows:

1. This research leads to the creation of a database of startup which can support design thinking practices and a consequently analysis has been performed. The sample is composed of 612 startups which operates all over the world. From this information it is possible to understand the structure of the ecosystem from many viewpoints. It could be in the interest of managers understand how design thinking is adopted and where the main investments are located in order to identify major opportunities. In this sense, it is useful understand the winning pricing strategies or the adoption of the different approaches. Moreover, it is possible to fully explore the various solutions which can sustain this innovation process: for instance, the impact of the new technologies on the different metaphases. All these different factors could be useful both for managers which want to effectively support the innovation process inside their organization and for the ones which want develop solution that aims at support design thinking processes.
2. Moreover, an in-depth multiple business case study investigates about the support of the artificial intelligence to the design thinking process. Again, the

results might be useful to practitioners belong to both sides: the ones which provides the solution and the one which use it. It is possible to understand how effectively use AI during the different steps of the process, to grasps which are the major constraints and how could be used in the future. Indeed, it is shows how AI can effectively replace human by automating some activities during the first phase of the design thinking processes. Moreover, how create synergies between human and machines during the ideation phase in order to reach superior performances. Furthermore, how the AI can be used in the final steps, to understand feedback and refine the solution. All this evidence allows to improve the design thinking process by effectively adopt AI solutions.

4.4. Limitations

This study is clearly affected by limitations. The first one emerged during the creation of the startups database: indeed, at the beginning of the extraction of data from crunchbase.com it is possible that the set of tags was incomplete in order to extract all the startups related to the theme. Then, the selection of the startups was performed with a subjective choice and, despite the willingness to not be affected by biases by checking multiple time, it is possible that valid startups have been excluded from the sample. This is due to the consideration or not of startups which were in a 'borderline' situation and to the potential lack of information on the website of the company. The second limitation is related to the results of the case analysis: indeed, the result could be affected by biased despite the formulation of a solid protocol. Moreover, the results deriving from interviews, although cover all the metaphases of the design thinking process, exclude some interesting viewpoints such as the impact of AI on the team formation or on rapid prototyping. This limitation is present also if it is considered the design thinking approaches indeed, there is not the presence of a companies which support the 'innovation of meaning' approach. These constraints are due to the limit presence in the sample of companies which adopt these kinds of solutions and, despite being contacted, their refusal to sustain an interview: most of the time due to the limited size of the team and, consequently, lack of time. This results in lack of evidence which could be

useful to completely answer to the second research question and fully describe the impact of AI on design thinking processes.

4.5. Future work

This field is still unexplored, so there is vast room for improvements in further research. First, it could be of interest conduct a map of the ecosystem periodically in order to understand the evolution and the development of the scenario. This can lead to the generation of useful insights in terms of new trends and consolidation of the practice. Moreover, considering the second limitation, it could be of interest perform new interviews in order to confirm (or confute) the results of this research and enlarge them with a complete view considering also business cases which regard the use of AI in 'team building' or 'prototyping' steps as well as the 'innovation of meaning' approach. Another interesting analysis could regard how other kind of technologies support the design thinking processes, for example how AR and VR could enhance the collaboration and the co-designing of new solutions or how 3D printing can facilitates the generation of fast prototypes. The same analysis could be extended to incumbents and how they impact the realm of design thinking providing new useful insights to enrich this field of study.

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A Appendix

A.1. Startups' description

S1 *Year of foundation:* **2016** *Place of foundation:* **Houston, USA** *Total funding amount:* **$ 30,000.00**	*Design thinking approach:* **Creative Confidence** *Metaphases covered:* **'interpreting and framing'; 'ideating and conceiving'**

Value proposition

The AI platform learns from human experts and extract information from large unstructured data asserts to save time, cost and to de-risk business decisions.

How the startup leverages AI

The software is based on Intelligent Document Processing (IDP): It uses AI technologies such as natural language processing (NLP), Computer Vision, deep learning and machine learning (ML) to classify, categorize, and extract relevant information, and validate the extracted data.

How it works

The process starts by uploading of small sample of files that can be a mix of PDFs, images, Microsoft Office documents or text files. Then, the AI solution extracts user-defined attributes such as categories, text, numbers and graphical patterns with a confidence score. Finally, the information can be exported to a database, excel or queried with APIs.

Main clients

They are trusted by fortune 500 companies such as Schlumberger or Shell and by the US department of defense.

S2 *Year of foundation:* **2019** *Place of foundation:* **Vilnius, Lithuania** *Total funding amount:* **$ 1,077,858.00**	*Design thinking approach:* **Sprint Execution** *Metaphases covered:* **'prototyping and learning', 'launching and measuring'**

Value proposition

The service allows you to understand how consumers engage with your app, advertisement, packaging, landing page and so on before the launch. It is possible to validate the concepts for performance during the design stage with AI-generated attention analytics.

How the startup leverages AI:

Predictive eye tracking: the AI recognizes particular patterns in user attention flow and systematizes them with heatmaps.

How it works

Firstly, it is necessary upload the file or digit the website URL and select the design type of the file (desktop, mobile or general) to understand where users will see the design. Successively, in seconds the software generates the result: a heat map indicates which design elements captivate the users' attention, with an indication on how much attention the object receives.

Main clients

They have strong partnerships with Google and Adobe. Among the clients there are big companies such as Vinted, OmnicomGroup and ISM.

S3 *Year of foundation:* **2018** *Place of foundation:* **Boston, USA** *Total funding amount:* **$ 290,000.00**	*Design thinking approach:* **Creative Confidence** *Metaphases covered:* **'interpreting and framing'; 'team building and task management'; 'ideating and conceiving'; 'collaborating and co-designing'**

Value proposition

They offer aims at teaching faster, learning more and building better. They help diverse teams do their best work in a flexible way.

How the startup leverages AI

When users ask questions, the platform gather them, rate them, and AI measures the quality of their content through machine learning. It also tracks every team member thought process, measuring the quality of ideas teams choose to focus and automatically maps thinking.

How it works

The platform records the questions of the innovation team during the brainstorms. It understands the level of understanding related to the problem to solve and provides different tasks to each member to develop new knowledge. Moreover, each step of the ideation process is recorded, and the final output is a mind map which relates different topics.

Main clients

The startup works a lot in education where it worked for universities like Arizona State University or Georgetown University. Moreover, they collaborate with US Air Force to help them in communication, training and innovative thinking. Nowadays, they are trying to effectively provide their service to companies.

S4 *Year of foundation:* **2018** *Place of foundation:* **Edinburg, UK** *Total funding amount:* **$ 2,161,174.00**	*Design thinking approach:* **Sprint Execution** *Metaphases covered:* **'interpreting and framing'; 'ideating and conceiving'; 'collaborating and co-designing'**

Value proposition

The solution provides to customers more options and greater details much earlier in projects.

How the startup leverages AI

Optioneer is based on AI and cloud technologies. It integrates constraints and models from all disciplines to give a complete view of the project working with a multi-criteria analysis.

How it works

The workflow is composed from simple step. Once the data are imported, there is the configuration of parameters and the generations of options. Together with the intervention of the experts there is the assessment of the output which refined through an iterative process.

Main clients

Among the many customers there are companies such as: Mott Macdonald, SGN, ATKINS and Mainstream Renewable Power.

S5 *Year of foundation:* **2018** *Place of foundation:* **Sundsvall, Sweden** *Total funding amount:* **$ 300,000.00**	*Design thinking approach:* **Creative Problem-Solving** *Metaphases covered:* **'sensing and empathizing'; 'interpreting and framing'; 'launching and measuring'**

Value proposition

They offer not just the most cost-effective people counter with insights, but also a privacy-friendly solution that ensures the customers' future needs.

How the startup leverages AI

They are a computer vision company based on 2D cameras. Thanks to AI they capture data and then anonymize them. Then with machine learning calculates insights.

How it works

The software analyses the images captured through the cameras in the physical stores. It develops a customer journey mapping which allow to understand customers' behaviors. The dashboard allows to fully grasp the retail insights generated regarding how much the strategies are effective and where customers lose their interest through heat maps.

Main clients

Their offer regards physical retails and mall. One of their main investors is IBM Sweden.

S6 *Year of foundation:* **2017** *Place of foundation:* **Austin, USA** *Total funding amount:* **$ 23,623,877.00**	*Design thinking approach:* **Creative Problem-Solving** *Metaphases covered:* **'sensing and empathizing'; 'interpreting and framing'; 'ideating and conceiving'**

Value proposition

The platform serves as a single access point for the entire organization, making all the customers' data accessible, actionable and reusable.

How the startup leverages AI

It is a feature-oriented database platform that powers real-time analytics and machine learning applications by simultaneously executing low-latency, high throughput and highly concurrent workloads.

How it works

The solution extracts feature from raw data at the source, even if they are in a multitude of data centers. The platform is stored in-memory in a high-performance machine-native format. It allows to extract useful insights and make sense of the data, by allowing to instant decisions with fresh data.

Main clients

Among their customers there are: Q2eBanking, Subspace and IT Technology Infrastructure.

S7 *Year of foundation:* **2015** *Place of foundation:* **New York, USA** *Total funding amount:* **$ 2,238,125.00**	*Design thinking approach:* **Creative Confidence** *Metaphases covered:* **'sensing and empathizing'; 'interpreting and framing'; 'ideating and conceiving'**

Value proposition

The platform provides to humans a customized scrollable intelligence which allow to focus on the most important information. This facilitates the understanding of new topics.

How the startup leverages AI

It is a web app based on machine learning and deep learning. It uses natural language processing algorithms to read articles, categorize them and generates insights.

How it works

The platform scours the web for new articles based on topic of interest and analyses them instantly. It extracts the intelligence in a searchable databased. Then the intuitive interface makes it easy to drill down to whatever level of detail the customer requires, revealing hidden insights.

Main clients

They have many customers, for example: HDFC Bank, Club Mahindra, CooperStandard, Wacker and DFM Data Corp.

S8 *Year of foundation:* **2015** *Place of foundation:* **Mumbai, India** *Total funding amount:* **$ 2,000,000.00**	*Design thinking approach:* **Creative Problem Solving** *Metaphases covered:* **'interpreting and framing'; 'ideating and conceiving'**

Value proposition

The software helps the customers to make data-backed decisions by translating complex datasets into simple language.

How the startup leverages AI

The software use AI to analyse any source of data. Then, it is possible to ask questions to a conversation interface based on natural language processing.

How it works

The solution allows to integrate and unify data from different sources all in one place. Then customers can access to AI-powered insights and recommendations, revealed using advanced analyses such as predictive or diagnostic analysis. Successively, it is possible to ask questions to data and receive actionable insights in natural language.

Main clients

Among the main clients there are: Accenture. ABB, HDFC Securities, Sanofi and Yes Bank.

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Acknowledgments

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