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Maker Movement and Automotive 4.0: analysis of the New Industrial Revolution enhancing Product Customization

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Firma dello studente

Francesca Calicchia

A mia madre,
faro luminoso, luce nella tempesta,
Che mi ha insegnato a non mollare mai, perché noi siamo più forti della vita.

A mio padre,
pietra antica e solida, sostegno e protezione,
Che mi ha insegnato che i sogni sono una cosa seria, e possono diventare realtà.

“Non sappiamo mai quanto siamo alti finché qualcuno non ci chiede di alzarci
e allora, se siamo conformi al progetto,
le nostre stature toccano i cieli.”
Emily Dickinson

Table of Contents

Index of Figures

Index of Tables

0. Introduction

The purpose of this dissertation is to study the impact of Industry 4.0 tools in the Automotive sector and at the same time understanding how some technologies can disrupt and someway change the everyday people's lives and habits. Some disruptive innovations, like Additive Manufacturing, already introduced big changes and opportunities inside the market, and lots of other evolutions are expected to become real in the future. These new technologies are affecting not only companies and manufacturers, but are creating new aggregations environments for hobbyists and passionate people that find in the New Industrial Revolution great opportunities for finding solutions to their everyday problems. The dissertation has the purpose to analyse the phenomena from various point of views, understanding causes and effects of one of the biggest revolutions at all.

FIRST CHAPTER – In this first chapter, the main goal is to offer an overview of the changes that have taken place since today on the consumer side, and how some 4.0 technologies have transcendently influenced the way in which the end consumer relates to and collaborates with companies or with other consumers to reach a solution to his problems. The chapter starts by offering an introduction of the Maker Movement and its characteristics. Starting from Chris Anderson definition, it is depicted a panorama of the new, big and significant movement that was born thanks to the democratization of new technologies. The spreading of Makerspaces and FabLabs are concurring to the diffusion of this technologies. Customers today, more than ever, started to have a voice, to express their need, to ask the market what they want, or other way, to create themselves what the market could not offer. The chapter introduce then the new Web 2.0 instrument that are allowing for the first time the customers to be connected and to be heard by customers, moving towards C2B – Consumer to Businesses – business models. The Web 2.0 concurred in the diffusion of instruments and tools enhancing Product customization, Crowdsourcing and Co-production and Co-creation with customers, making business more and more open – in an Open Innovation perspective.

SECOND CHAPTER – After providing an overview on the innovations in the customers' perspective, in the second chapter we go in depth analysing the Industrial Revolutions. The chapter starts giving a short overview of the precedent three revolutions that, before the last one, made significant changes in the global environment and someway affected irreversibly the way of companies of doing business. The chapter then introduces the Fourth Industrial Revolution, with a focus on the 9 Industry 4.0 tools identified by Boston Consulting Group (2015). In the end of the chapter it is introduced the Manufactory sector in a 4.0 perspective, analysing how the conversion from Traditional to Digital Manufacturing is positively affected by 4.0 tools. An in-depth representation on the Italian Manufacturing situation is presented.

THIRD CHAPTER – After introducing the Industry 4.0 on a global perspective, the third chapter aim is to focus on the Automotive sector. In this chapter the Automotive sector is analysed from different point of views. Firstly, a worldwide overview on the Automotive market conditions, presenting the global demand and production, and the main producers Countries and the main global players. Then, a focus on the Italian environmental context. After this introductive paragraph, there is a focus on the main trends in the Automotive sector: Green Mobility and Smart Mobility. Furthermore, in this case we analyse the main producers and adopting countries and the major players in the sector. In the last part of the chapter, six of the main global OEMs have been analysed regarding their commitment and implementation of Customers' Personalization related tools and initiatives and regarding the adoption of the new trends in 4.0, green and smart mobility.

FOURTH CHAPTER – The fourth and last chapter has the man objective to present some cases as real examples of companies adopting 4.0 technologies and enhancing Product Customization. The first part of the chapter presents three international example of car manufacturers that introduces very innovative business products and production systems. They provide a real example on how Industry 4.0 tools and Web tools allows for offering to the final customers a product with a high level of personalization enabling the company to reach flexibility in terms of times, cost-reductions and efficiency. The second part of the chapter is an exploratory analysis on the customers' side. The objective of the research – that have been submitted to various international makers communities – was to understand the relation between makers and the Automotive sector, and to analyse how importance the final customers give the their cars' customization, and at a final pace if they are willing to exploit their makers activities to obtain personalization products and tools for their personal car.

1. Maker Movement

> *Making is fundamental to what it means to be human. We must make, create, and express ourselves to feel whole. There is something unique about making physical things. These things are like little pieces of us and seem to embody portions of our souls.*
>
> Hatch, 2013

Make, share, give, learn, tool up, play, participate, support and change are the cornerstones of the Maker Movement Manifesto (Hatch, 2013). This is not a simple definition, but it encompasses some of the fundamental characteristics of the human being and his expression throughout the whole history. As the Soviet psychologist Lev Vygotsky explained in his theory, creativity allows men to step into the future, changing the present condition. Creativity exists wherever there is a man able to imagine, combine, modify or realize something new: it is an essential condition of humans. The huge potential of the human mind must not be undervalued, because it can represent a new and precious source of value, not only in the developing countries, but also in the developed one. In a global economic environment that is becoming increasingly competitive, the benefits that can arise from individual's participation to the innovation processes are fundamental to economic prosperity. Understanding the history and the evolution of the Maker Movement, that is in a sense understanding the characteristics and the potentiality of people in general, allows to give an answer to the challenges of the new era and help firms to create new, sustainable, open business models that are aware of the opportunity they have both inside and outside their firms, just encouraging and exploiting people's creativity and passions. Some companies have already started to recognize this potential, searching for "soft-skills" when they are looking for new employees. The Collins English Dictionary defines soft skills as *desirable qualities for certain forms of employment that do not depend on acquired knowledge*. A research from Guy Berger (2016), an economist of LinkedIN, mentions in the list of the most in-demand soft skills among candidates for a new job: communication, critical thinking, creativity, teamwork, social skills, interpersonal communication, friendly personality and adaptability. In an innovative context, while companies are changing the work environment introducing automation, robotics, big data and virtual communication, the real turning point may be not in AI and algorithms, but in the potential of the human intelligence. This is our competitive advantage in respect to technology: our intelligence, our critical thinking, the capacity to allow the change (The Adecco Group, 2017). Our critical thinking and intelligence, as well as our creativity, is something intrinsic in the human being: this is the reason why we can find some evidence of the rise of the Maker Movement since the ancient time. The man who discover the fire, or the one that created the first wheel, wasn't he a maker? (Toschi, Benedini & Micelli, 2018). Since the beginning of our history, humanity developed thanks to men's curiosity and creativity, going along with the natural effort to improve and search for "innovations", in a timeline that resemble more a spiral, or a sliding scale in which – in a Schumpeterian view (1912) – the innovative man is able to break from the ordinary habits and push the society, and at the same time the economy, a step ahead in the progressive scale. According to this view is obvious to state that Makers were born with humans, and all the innovators, scientists, researchers and discoverers that exists over time, they were all Makers. "Leonardo was the first Maker in the history", said Leonardo La Rosa, director of Leonardo Da Vinci Experience Museum in Rome, in occasion of the edutainment show "Da Vinci's Coding" (2019), in which they celebrate the 500th anniversary from the death of the genius. The show was an educational trail in which they utilized robotic and modern technologies to simulate ancient Leonardo's machines and inventions. This exhibition is a clear evidence on how much different but how much closer are the ancient makers and the contemporary ones. The main difference is strictly connected with the innovation and the revolutions we are coping with in these years. Contemporary Makers are something like the genius of Leonardo Da Vinci connected with the web, the robotics, the automation: nowadays makers are interconnected, they do not have problems of distance, of communication, of information sharing, they don't even have problems of production and manufacturing. Modern Makers, although they do not have homogeneous objectives and scopes and they are motivated by different and various reasons, they are de facto enabling new models of education, collaborative work, and manufacture (Rosa, Pereira & Ferretti, 2018).

Some researchers trace the origins of the Maker Movement around 1970s, in those years in which personal computers and the availability of latest technologies gave individuals the chance to implement free time activities and that way to exploit new opportunities of social emancipation (Lindtner, Hertz, & Dourish, 2014). In the present environment, the Maker Movement activity developed into re-creation and assembly of products, utilization of new technologies like 3D printing and laser cutting for prototyping: all activities that show a strong creativity orientation and hands-on approach, where learning by doing become an inevitable condition. If we try to fix a working definition of *making* as a class of activities it must be *something focused on designing, building, modifying, and/or repurposing material objects, for playful or useful ends, oriented toward making a ''product'' of some sort that can be used, interacted with, or demonstrated* (Martin, 2015).

One of the most shared and accepted definition of the Maker Movement is the one given by Chris Anderson, author of the book “Makers. The New Industrial Revolution” (2012): Maker Movement is recognized by mainly three characteristics:

1. There are people that are using digital desktop tools to create designs for new or modified products and prototype them (“Digital DIY”).
2. Exists a cultural norm to share those design and collaborate with others in online communities.
3. There is a common use of design file standards that allow anyone to send their designs to commercial manufacturing services to be produced in any number.

This definition highlights some of the key concepts of the Maker Movement: the first one is about digital desktop tools. Anderson wants to underline the fact that, with modern prototyping, people, and in the specific makers, have the possibility to get almost free access to digital tools like CAD programs, where you can design 3d objects on screen even if you have zero or little knowledge of 3d prototyping and moreover you have also the possibility to decide to “print” those object with your own 3d printers – that you can buy with a modest expenditure – or send the 3d file off to a service bureau that manufacture in volume for you. The second concept underlined by Anderson relates to the *sharing* principle of the Maker Movement Manifesto. For Makers’ Communities it is important to have free access to the designs of everyone else in the community and have the possibility to work on them. This principle is far away from the concept of Intellectual Property Rights: the reason of this aspects lies in a simple truth that differentiate makers from producers, and it is their final objective. Makers, as we will specify in the next paragraphs, use to implement radical or incremental innovations especially for their own benefits, to solve some problems they incur in or to have personal satisfaction, while producers have as final aim the commercialization. Producers need to protect their inventions in order to prevent any other firm to detect the innovation and commercialize the same product or service on the market. But for makers this is not true: makers need to share innovation because this is the only way that allows them to reach the solution they are searching for in a shorter time or in a better way, or simply because they don’t care about others to implement the same product they invented because they already solved the problem they had. This principle is also connected to the paradigm of Open Innovation introduced by Henry Chesbrough (2006) that is opposed to the Closed Innovation system, in which companies are suggested to open their “boundaries” and look for external collaborations in order to remain competitive in the new technological environment. Open companies are suggested to out-license - to license unutilized or underexploited patents to external firms in exchange of a remuneration – and in-license. Differently from makers, open companies are not asked to share everything without distinction and protection at all – this would be insane for a firm and its profitability – but to make a smart use of their patents and exploit the maximum potential from them. The last concept defined by Anderson is the use of standard files in order to allow easy scale manufacturing. As we mentioned before, the new technological revolution allows people to produce physical objects even without owning the means of production, just placing an online order and uploading a design file. For this reason, it is important that inside the communities the files are shared in a common standard in order to allow anyone to "speak the same language", from the other makers to the company that will eventually manufacture the products. A further definition of the Maker Movement is given by the Foresight, Behavioral Insights & Design for Policy Unit of the Joint Research Centre (JRC) of the European Commission (EC) in a report of 2018. There are some inbuilt values that define the Maker Movement and on which Makers that have been interviewed for the report agree on:

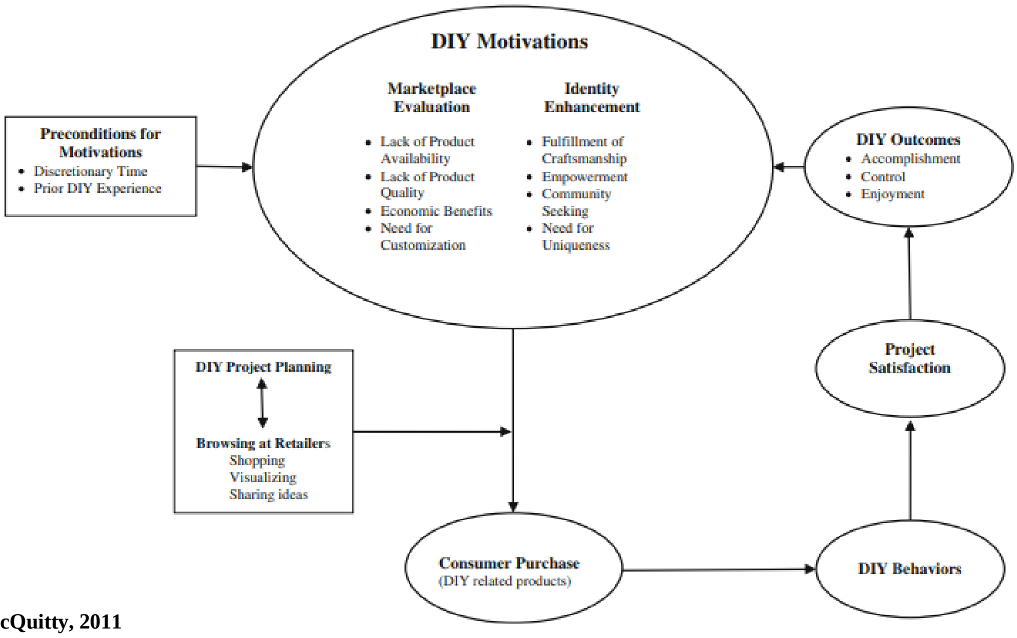
- **Innovation**: Makerspaces deal with the creation of new products and the development of start-ups. Innovations are seen as opportunities to develop customized and unique solutions especially at a local scale as opposed to the mass production paradigm.
- **Skills**: To become a Maker is fundamental to develop new skills, upgrade the existing knowledge and acquire flexibility to face everyday challenges. The Maker Movement is conceptualised as a promoter of new skills, such the ones identified by Guy Berger in the recruitment process.
- **Open everything**: Open source is strictly related to the concept of Makers communities and exchange of designs, data and information. Established that open collaboration is extremely simple within makers' communities, a further consideration should be made regarding the collaboration between makers and companies: to implement an open business model should be also a prerogative of companies that wants to foster innovation and be economically sustainable during time.
- **Sharing**: All the definitions of Makers agree on the sharing paradigm: it allows to connect people, to spread knowledge, tools and resources available to the community.
- **Fantasy**: Makers are expected to be individuals that can freely express their fantasy and creativity without any external pressure.
- **Collaboration**: Makers need to develop a collaborative attitude inside communities, giving importance to the values of care and solidarity. Individuals are characterized by shared goals, creative ideas and mutual interdependencies. Collaboration is opposed to the concept of competition, and it can be considered as a strong driver to foster innovation.
- **Education**: Maker Movement proposes a model of education that relies on the principle of learning by doing: experiential, hands-on, experimental, and peer to peer learning. These

concepts are not offered as substitutes of formal modes of learning, but they could and should co-exist.

- **Fun**: Makers' aim is personal development: making is often characterised by fun and hobbysm. To have fun in one's work is a strong inspiration for how work could be imagined in the future, exploring ideas of personal fulfilment way beyond the pay check objectives.
- **Time**: Makers have a certain autonomy in the management of the time at their disposal. This is especially true for those makers that utilize their free time explore and develop innovative products/services and interact with the makers' community.

What we can notice by looking at different definitions of the Maker Movement is the delineation of some peculiar characteristics such as creativity, openness, collaboration and personal satisfaction. Referring to the Maker Movement definition by Chris Anderson, it is introduced another important aspect related to the argument, that is the Do It Yourself Movement. Do it yourself is the process designing, creating or modifying any particular object or product when it is accomplished by an individual, rather than a professional. It is defined as *activities in which individuals engage raw and semi-raw materials and component parts to produce, transform, or reconstruct material possessions, including those drawn from the natural environment* (Wolf & McQuitty, 2011).

Figure 1. A conceptual model of the motivations and outcomes of DIY behaviors



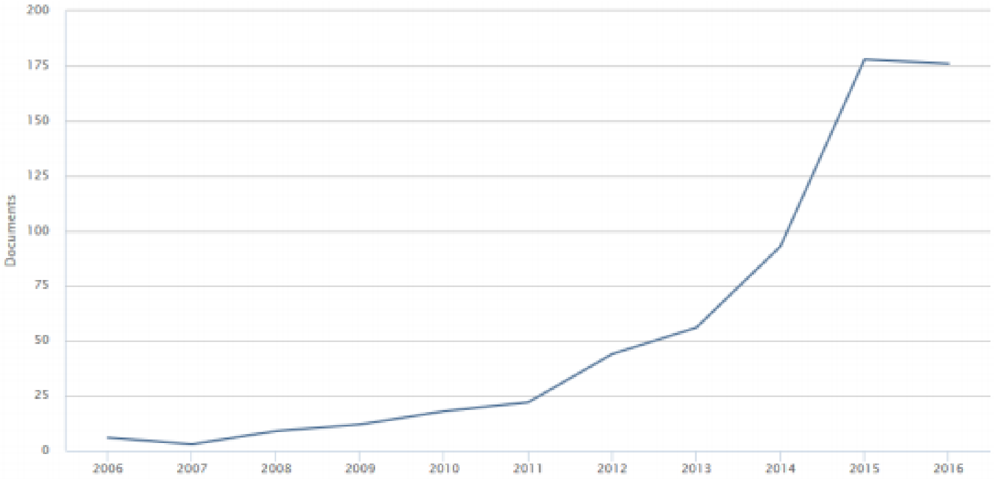
Source: Wolf & McQuitty, 2011

The **Fig.1** gives an insight on the DIY movement and in the specific on the motivations and the outcomes of the DIY behavior that can be useful to let marketers have ideas about new possible value propositions. Basically, there are two main reasons why customers engage in such activities: Marketplace Evaluation and Identity Enhancement. DIY activity facilitates customers in their make-or-buy decision, especially in those circumstances in which they are experiencing dissatisfactory products or services, for example due to a lack of product availability, dissatisfactory product's quality and the need for product/service's customization not available in the market. At the same time DIY activity allows customers and individuals in general to enhance their identity by fulfillment of craftmanship passion, by the participation in a community, by the research for uniqueness and the consequent personal satisfaction. This activity originated from the personal work of individuals allows the creation of new value that is derived through crafting material goods. Identification with the product is a recurring concept for makers and craftsmen in general, and even if it seems something normal in the actual environment, it can be considered a revolution. As Chris Anderson state in his book "*If Karl Marx were here today, his jaw would be on the floor*": the concept of worker's alienation from the product of labour and from the labour itself is completely overturned with DIY movement where identification become one of the main reasons of the activity. The alienation of labor stems from the fact that *labour is external to the worker, i.e., it does not belong to his intrinsic nature; that in his work, therefore, he does not affirm himself but denies himself, does not feel content but unhappy, does not develop freely his physical and mental energy but mortifies his body and ruins his mind* (Marx, 1844). The worker is not anymore sad, alienated and frustrated individual working for someone else *controlling the means of production*, but he has now the power and the autonomy to work for what he cares and to produce what he really needs. Making object for yourself is more personally fulfilling than making them for someone else; the modern worker has the possibility to express his creativity, to decide its needs, to participate in the ideation, design and production phase, to adjust and develop products, to decide time, modality and effort of his work. Those aspects are in a close relation with the DIY outcomes shown in the **Fig.1** that are accomplishment, control and enjoyment. Outcomes are not important just for the individuals involved in the process but also for external individuals and most of all for companies.

Companies and retailers have interest in DIY outcomes because usually those are improvements of existing products or ideation of new ones in order to satisfy someone's needs. Those improvements may be freely available for companies and allows to satisfy a greater number of customers, that is the reason why they should not be undervalued.

DIY and Maker Movement are having greater importance in the worldwide economic scenario and various studies and data give evidence on this trend. The Atmel Corporation, a worldwide leader in the design and manufacture of microcontrollers, has calculated that there are approximately 135 million adult Makers in the United States (2015). This is over half (57%) of the American population and does not include the millions of children and teenagers who are active in makers' projects through science fairs, robotics teams and tinkering in their basements. In 2013 the do-it-yourself (DIY) home improvement industry in the United States was worth over $700 billion. The hobbyist segment was worth over $25 billion. The most valuable segment of the $700 billion DIY was the perpetual remodel, especially those who have enough money to let business professionals do the work for them, but don't (Hatch, 2013). To enhance the importance of the Maker Movement just think that in June 2015 President Barack Obama proclaimed the National Week of Making, calling upon all Americans to observe the week with programs, ceremonies, and activities and to encourage a new generation of makers and manufacturers to share their talents and hone their skills (Presidential Proclamation - National Week of Making, 2015). The Etsy platform, a craftsmanship marketplace, in which Makers from all over the world posts and sell their handmade and vintage products, counted in 2018 2.1 million active sellers, the most of whom came from United States, United Kingdom, Canada, Australia, Germany and France (Etsy Annual Report, 2018). In the European Union, and especially in those nations in which the craftsmanship and small manufacturing industry has a dominant role in the economy, Maker Movement is becoming a growing phenomenon that is capturing the attention not only of enterprises but also of governments. In the **Fig.2** is recorded the number of published scientific articles mentioning the wording 'Maker Movement' or 'Makerspace': as we can see in the last years – starting from 2011 – there has been an upward trend of mentions, meaning that there is a growing interest in the subject among researchers (Rosa et al., 2017).

Figure 2. Number of published papers (yearly) with mention to the Maker Movement



Source: Rosa et al., 2017

The Maker Movement has the potential to change and shape the world in small but significant ways. It can affect society and spread new values that are crucial in the future working environment to face the global competition and the new technological challenges. Maker Movement is *nurturing the creation of tinkering environments in which individuals engage and adapt their physical world in a meaningful way through making and hands-on practices (Rosa et al., 2018).* It is a phenomenon that is changing the working environment by shaping the way of doing innovation. Maker Movements should be properly supported because it is able to offer new opportunities to workers and companies and to create new sources of value, especially for those countries, like Italy, in which the small, local enterprises have a big prominence in the national economy. Makers are the leaders of the Fourth Industrial Revolution, they put the sharing of knowledge and technology at the base of a production system and, more generally, of an innovative, dynamic economic system capable of creating value even in a period of crisis and increasing global competition (Reboani, 2015).

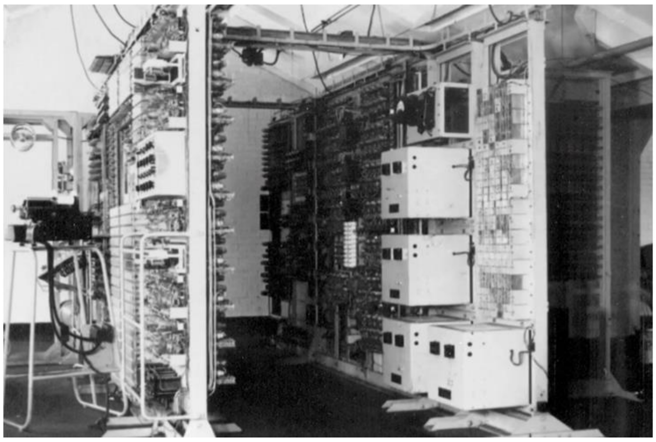
1.1 Democratization of new technologies: from bits to atoms

There is no true progress if technology is not within range of everybody.

Henry Ford

If we look at the history of Makers, we already assumed that they exist until the first man appeared on the world. But what is really changing between the first man who invented the wheel and, for example, Mark Zuckerberg that developed Facebook in his garage? They were both inventors, someway. They both made a change in the history of the humankind. But they were not both entrepreneurs. This is the key concept to understand in which ways the modern technologies affected and are affecting the new inventions and productions. Modern Makers can benefit from the spread of web technologies in many ways: the most important is the easiest transition to get from an inventor to an entrepreneur. *The great inventors and businessmen of the Industrial Revolution, such as James Watt and Mattew Boutlon of steam- engine fame, were not just smart but privileged* (Anderson, 2012). To become entrepreneurs, they must have been lucky enough to be born in the middle-high class of the society, in the elite, in order to exploit the opportunity that their position gave to them in order to start to run a business.

Figure 3. Colossus, the first world processor



Source: Byford, 2012

Today, thanks to the web, we are witnessing the democratization of both the tools of invention and production, by reaching levels of users' autonomy that until some year ago were unimaginable.

The democratization of technology started with *several innovations that came together in the 1980s involving computerization, telecommunications, miniaturization, compression technology and digitization* (Friedman, 2003). The first world processor in the history is *Colossus* (**Fig. 3**). It was created by Tommy Flowers at the Bletchley Park decryption centre in England, during the Second World War with the purpose of intercepting and decrypting German enemies' messages (Byford, 2012). It costed millions and it was big as an apartment: not exactly what do you expect when you think about a tool available for the major part of the population. In contrast, according to Moore (1965), that before everyone understood the emerging trend of the modern digital revolution, the computing power has dramatically increased and the related costs have significantly diminished at an exponential rate: nowadays you can buy a computer for some hundred's dollars, you can put it easily inside your bag and utilize it wherever you want. Even children have easy access to personal computers. In 2018, approximately 259.39 million PCs were shipped around the world (statista.com, 2019). The Internet World Stats estimated that in April 2019, 56.1% of the world's population had internet access, and 81% of the developed world. Europe and United States are the Countries that register the most personal computer per Capita, with Switzerland at the first place – 65 personal computers per 100 inhabitants – followed by United States – 57 computers per 100 residents – and Sweden and Denmark – both 51 computers per 100 residents (Worldatlas.com, 2017). The democratization of technologies allows for a rapid accessibility, affordability and ease of use of technology for today's users and consumers: this change is *enabling more and more people, with more and more home computers, modems, cellular phones, cable systems and Internet connections, to reach farther and farther, into more and more countries, faster and faster, deeper and deeper, cheaper and cheaper than ever before in history* (Friedman, 2003). Having a computer in your house, with an internet connection, enables you to do almost everything: you can have a retail store in your room, and choose the items to buy, even compare them, sometimes even to fit an item just making a picture and upload it on the online store, you can have a bank in your room, and made all transactions with a click, you can have a concert in your room, you can have your office in your room, you can have a bookstore, or a library in your room, you can have a school in your room, you can have a cinema in your room, you can even have a war in your room, and fight "shoulder to shoulder" to your soldier friends from all over the world – this is not actually my maximum aspiration but my brother do it almost every day, just with a computer, a pair of headphones and an internet connection. You can be wherever you want in your room, just going to Google Street View and putting the address you would like to go. You can be in a travel agency, meaning you can calculate costs, organize and book you vacancy at home. You can search for a work in your room. You can share whatever you digitally produce with all people around the world: articles, photos, paintings, books, statements, designs, projects, presentations, excel files, songs, voice records, videos. This overview is just to give a broad imaginary of the effects of democratization of technologies: it gave individuals not only opportunities but also the power to have access to a million of activities and tools. Technology becomes empowering and democratic when it provides a platform for participation, creates space for voices to be heard, allows information sharing, and facilitates relationships between groups (National Democratic Institute, 2017). A determinant phenomenon regarding democratization of technologies was the spread of desktop tools. When in 1985 Apple released the Laser Writer, the first desktop laser printer, is was a dropping moment in the technological environment: it was the first time that the public imagination combined two words they have never been together before: *desktop* and *publishing* (Anderson, 2012). With this event the publishing world in a sense shifted in the hands of everyone. In fact, in that time publishing was strictly connected to the act of manufacturing: no one could print something in his room, but you needed a real factory, with huge rolls of paper and barrels of ink. It is true that the publishing world is still existing, and the spread of desktop printers made little or no significant impact to the professional manufacturing, but it is also true that it gave people the power not just to write something in *bits* and share it virtually, but starting to transform the bits in *atoms*, eventually printing a prototype of their publication to check it at home before placing the biggest order to a professional manufacturer. But the real impact of desktop publication was *not in paper, but in the idea of publishing online* (Anderson,2012). The interest of people shifted from printing newsletters and other editorials outcome to *posting*: the exploitation of web connected to the computer allows individuals to share materials without the necessity to print it. This was particularly supported by new sharing formats like Facebook, Instagram, Blogs, Communities Online, Webpages that interconnected people from all over the world. In a couple of years, as Moore predicted, the technology completely modified the relationship between individuals and automated tools in their everyday life. This trend forces even companies to rethink themselves in order to meet new customers' habits and needs. If it is true that computers made a great impact on human potential by giving people the power to create and to spread virtual things in a quickly and inexpensive way, it is also true that the next step – that is already happened – regards the creation and spreading of physical stuff: atoms, not bits. *Just as the Web democratized innovation in bits, a new class of "rapid prototyping" technologies, from 3-D printers to laser cutters, is democratizing innovation in atoms* (Anderson, 2012). 3-D Printing is a process for making a physical object from a three-dimensional digital model, typically by laying down many successive thin layers of a material. It brings a digital object - its CAD representation - into its physical form by adding layer by layer of materials until the object is finished. Until the 1980s the only way of fabrication conceived was the traditional subtractive fabrication, from which a machine worked by subtracting raw material from a bigger piece in order to obtain the final output. With 3-D printing there was the introduction of the so-called additive fabrication: 3-D objects are produced by adding layers of material starting from nothing, instead of removing useless material from a full block (Savini, 2015). 3-D printing allows people not only to imagine, but to really create in the real world a product: the people now controls the means of production. They can even have a factory in their room, and they will produce with high complexity and quality at low cost. Consider also that the average consumer 3-D printer costs around 700 dollars, and the cheapest one starts from around 200 dollars and that consumer 3-D printers are generally very simple to use – they don't need a specific professional training. This means that you can have a factory for 200 dollars, producing objects that you ideate, create, imagined and designed on CAD program, wherever you want, whenever you want: Marx would have been so happy if it knew about the future. Thinking about the fact that today is quite normal to have a computer in your house, it is normal to have an ink-printer in your house, we can imagine that in a few years or decades it would be absolutely normal to have also a 3-D printer in your house – my cousin still has one for some years. And you could have 3-D printers also in schools: we can just imagine the impact of this introduction. It is very important, in light of these facts, understand that a change starting from the educational system is needed, in order to create young adults that are aware of the opportunities given by those advances in technology and to prepare them for new working environments that will inevitably emerge in the most innovative companies, but also in the least ones. We can imagine that in a near future computers and 3-D printers will not only be an integrant part of every innovative company, but they will in fact be embedded with our environment, inevitably occupying our physical world as ordinary elements, enhancing our human capabilities and our environment. Mark Hatch, CEO of TechShop, explains that "*with the right motivation and time on your hands, you can now go through your own personal industrial revolution in 90 days, and can launch a company or product within those 90 days*." (Hill, 2015). As mentioned at the beginning of the paragraph, democratization of new technologies allows to make the two concepts of inventors and entrepreneurs converge in a unique one, like nothing before. And for the very first time after Marx alienation, individuals are free to be creative, to be inventors, and to decide with no particular risks and investments to become entrepreneurs: this is the social boost that has led to the creation of the Maker Movement. New democratization of technology introduced also another trend on the economic environment: on-demand factories. On-demand factories are open factories that are offering a Web-based manufacturing service to all those makers that have a digital design in their hands – or better in their computers – and a credit card (Anderson, 2012). Those factories are allowing Makers to go into production without a manufacturing plant and even without a 3-D printer: just uploading a digital file. You can order a production with the ease with which you can order a pizza: laying on your sofa. The rise of on-demand factories – or manufacturing platforms – may turn out to be the biggest tech news of 2019, by allowing companies and makers to rewrite the production rules. This will create for instance new opportunities for local manufacturers. Thinking about the existing trends of outsourcing and factory-less production, where manufacturers have been increasingly separated from design and marketing, on-demand platforms may seem the most logical outcome. But with the Internet of Goods, that is the process of digitalizing physical industries, such as manufacturing – for example by putting sensors into existing products such as turbines and tractors, and using the resulting data to improve performance – on-demand platforms are carrying the process to the next level. *Manufacturing platforms will be an essential driving force for the digital factory boom of the next ten years* (Mandel, 2018).

“There is no need for anyone's permission to do great things”, this is what Massimo Banzi, cofounder of Arduino, said about new Industrial Revolution. Arduino is an open-source electronics platform based on easy-to-use hardware and software. It was born in Ivrea in 2003, at the Interaction Design Institute by some researchers. Arduino allows to put an "intelligent heart" into common products, for example lamps, furnishing objects and household items, in order to expand the artistic dimension and develop possible interactions with the user.

Arduino contributes in substantial way to the birth of the Internet of Things, by giving the possibility to interconnect objects of any kind, not necessarily with the computer: for example, a bin garbage that communicates with the ecological platform or a plant connected to the Irrigation system (Edizioni Atlas, 2015). Arduino is an Italian example of what democratization of technologies can do by empowering anyone to modify, create, and most of all to connect objects among themselves and with humans. It combines bits and atoms in order to create new, unexplored opportunities in the world of real things. Thanks to Arduino even someone with a low budget and little technical background, can realize and transform electronic objects.

The Internet of Things, along with 3-D printing, *could be the transformative technologies of the 2015 – 2025 period:*

> This has the potential to remake the economics of manufacturing from a large-scale industry back to an artisan model of small design shops with access to 3-D printers. In other words, making stuff – real stuff – could move from being a capital-intensive industry into something that looks more like art and software.
> (Rich Karlgaard, 2011)

Due to its magnitude on the glo0bal economy, democratization of new technologies is important not only for Makers, but also for companies – and in the specific for artisan companies – that have in creativity, hand-on approach and personalization their core activity and competitive advantage. Going in depth with the characteristics of this innovative tool allows to find solution for the increasing competition to which the manufacturing industry is subject and create new sources of value that costumers are looking for.

1.2 Fabrication Laboratory and Makerspaces

> *"Any sufficiently advanced technology is indistinguishable from magic"*
>
> Arthur C. Clarke

Maker community's sustainability depends in some particular cases on the physical presence: the diffusion of Makers came along with the spread of Makerspaces, that are physical places conceived for them to produce, share and learn within supporting environments. Active learning is enhanced by the awareness of colleagues' expertise and competence which are co-situated in a particular setting (Morreale, 2017). FabLabs – Fabrication Laboratries, Hackerspaces and Makerspaces can be seen as the physical representations of the Maker Movement. These unique places provide communities, but also businesses and entrepreneurs, the infrastructures and manufacturing equipment indispensable to turn their ideas and concepts into reality (Rosa et al., 2017). FabLabs are areas in which Makers can work with new technologies and digital fabrication instruments like 3D printers, 3D scanners, CNC machines – that differs from 3D printers because of their subtractive rather than additive technology – and Laser cutters, in a perspective of commonality and collaboration. FabLabs arise for democratize digital manufacturing (Nisi, 2018) since they allow already democratize fabrication tools to become even more accessible for people that can't afford to buy them or are just at the beginning phase of approaching to the Makers' world. In Fab Labs every passionate, professional, hobbyist that want to try some of the new transformation tools can simply rent it for the time he needs without have the burden to buy one or more machinery: these spaces have the manufacturing equipment that allows to turn digital files and concepts into real objects. Makerspaces also constitute vibrant and creative environments, in which you can meet other passionate and constitute a learning network, exchange knowledge, co-create and co-develop new ideas. Since Makers are usually non-professional members, they have incentives to freely collaborate, they are not motivated by economic reasons, and the collaboration become more productive since it doesn't suffer from opportunistic or protectionist behaviours. According to the European Commission (Rosa et al., 2017) FabLabs and Makerspaces respond to the following characteristics:

a) **Proximity**: having a common space allows members to meet and enjoy the time together by the consolidation of relationships. It also allows the organization of events, fairs, workshops and trainings to engage with the general public around themes of interest for the community.

b) **Educational purposes**: Makerspaces enable Maker community's members to go further in the connected learning environment. They are sometimes utilized by educational institutions like schools and university to foster educational purposes (*educational Makerspaces*).

c) **Entrepreneurship**: Makerspaces facilitated access to digital fabrication tools and technologies benefit mostly the generation of local businesses. Technologies allow the rapid prototyping of tangible objects with a high level of quality, making the design of new, highly customizable products risk-free and low-cost, especially for professional figures like architects, designers, and engineers that utilize them as innovation hubs.

d) **Self-support**: In general, Makerspaces members suffer from economic constraints, and utilize their budget for the equipment, supplies and organizing training activities. Community members have full access to the technologies, tools and spaces and the products they create usually ends up being sold in their networks: self-employment is a frequent aspect depicted in Makerspaces.

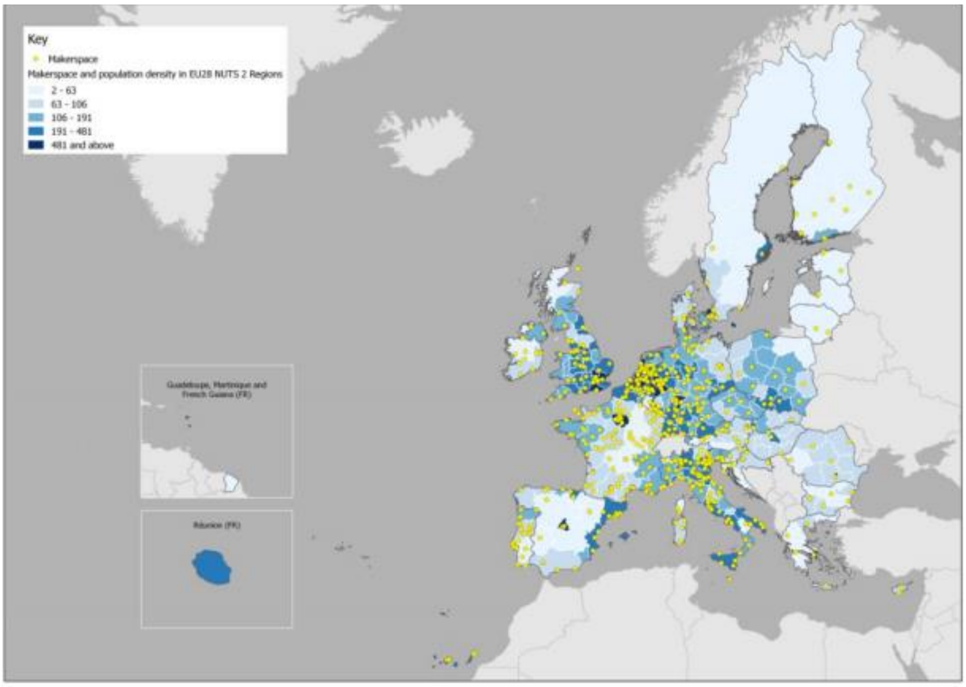
e) **Responsibility and ethics**: Makerspaces are by default oriented towards the creation of an environment that fosters the sharing of experiences and expertise. They promote the creation and exchange of open content and data, including open hardware and software. Sharing is an absolute pillar of the Maker Movement and it imply activities that are connected to improving the community's benefits. Some Makers' sub-movements, for example DIYbio, are raising ethical matters due to the fact that there are no regulations already existing in this area.

f) **Makerspaces as a model for engagement**: FabLabs offer unique opportunities for engagement of citizens by promoting more open and creative forms of engagement. Institutions such as museums and libraries are already starting to apply the principles of the maker culture by having their resources, facilities and collections available to the publics in a mode to stimulate cultural activities, critical thinking and problem solving. This hybrid form of Makerspaces promotes local knowledge spreading and supports cultural development.

Makerspaces constitution was a cultural revolution: in 2001, at the MIT (Massachusetts Institute of Technology) of Boston, a Physics professor opened the first Centre for Bits and Atoms, a Lab where you can create "almost everything". This was a milestone in the history, the first time people become conscious that with new technologies you can produce almost everything by yourself. Or better: by collaborating and sharing online with other people (Toschi et al., 2018). Neil Gershenfeld, today director of the Centre, had initially the aim to explore the implications and possible application of new technologies for personal fabrication in those Countries in the world where access to tools of fabrication and instrumentation was particularly difficult. The first FabLabs were created in rural India, Costa Rica, northern Norway, Boston and Ghana (Rosa, 2018), usually settled up commonly in the context of an institution, that could be a university, a company, an association or a foundation. FabLabs are today supported by the International FabLab Association, co-founded with the European Union, that has the main aim to disseminate FabLabs across the World, promote collaboration among them, as well as the share of expertise, the brainstorm of ideas and the spread of research. According to Fablabs.io (2019), the online social network of the international Fab Lab community, that started as a spin-off project in Fab Lab Barcelona by Tomas Diez and John Rees for the creation of an official list of Fab Labs, there are approximately 1000 FabLabs existing today located in more than 75 countries. People belonging to FabLabs communities are fabricators, artists, scientists, engineers, educators, students, amateurs, professionals aged from 5 to 75 and more. In USA the Obama administration has recognized the potential of the Maker Movement and it planned to introduce Maker spaces at 1000 Us schools and companies starting from 2013. The evidences show the spreading importance of Maker Communities not only in the developing countries but also in the most advanced one. They can provide different but very precious opportunities to different environments, but first of all they foster free innovation in cultural environments. A study conducted by Rosa, Ferretti, Pereira, Panella and Wanner (2017), outlined the diffusion of the Maker Movement across the European Union, highlighting the commonalities, characteristics, tools and strategies of more than 800 spaces. In the **Figures 4**. and **Figure 5**. it is depicted the geographic location of the Makerspaces within European Union and the total number of Makerspaces for each country, with a distinction between three main typologies: Hackerspaces, FabLabs and Others. The distinction made between Hackerspaces and FabLabs is essentially identifiable in some specific details. Both are spaces that arise in a community-based context, but Hackerspaces, more than providing the hardware tools and manufacturing equipment that you can find in a FabLab, they provide the learning environment and the necessary support for individuals to develop their projects based on their own interests. Hackerspaces are also all completely independent from each other's, although collaboration between spaces is quite common in FabLabs. The **Figures 4.** and **5.** shows a picture of a Europe in which Makerspaces are not equally distributed, providing an initial glimpse of a movement that is not homogeneous, both in terms of spatial distribution and identity. Western European countries have a higher number of Makerspaces with France, Germany and Italy accounting for more than half of the Makerspaces in EU – France accounting for 158 Makerspaces, Germany 151 and Italy 133, for a cumulative amount of 53% of total Makerspaces in Europe (442

Makerspaces on a total of 826 investigated). It is also interesting to notice that all major capital cities in EU have at least one makerspace, illustrating the spreading of the movement to all the countries and pertinent cities. Looking at the numbers, there is a considerable gap in terms of Makerspaces between the first three countries (France, Germany and Italy) and the subsequent three (United Kingdom, Netherlands and Spain). While the first three countries account for 442 Makerspaces, the following ones account for 162 Makerspaces. The discrepancy between the third country – Italy – and the fourth one – United Kingdom – is more than the half of the value, where Italy accounts for 133 spaces and UK has total 57 Makerspaces. A close analysis of the Makerspaces typology in the first countries shows that France has a higher number of FabLabs (72.2%) than Hackerspaces (21.5%) whilst in Germany the opposite occurs (FabLabs: 27.8% and Hackerspaces: 60.9%). The overall analysis looks completely different if we refer not at EU28 but at EU15 – Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden and United Kingdom. 92% of all Makerspaces are located in EU 15 member states, showing what already emerged, that the Maker Movement has considerably been built up in the Western countries. Consequentially, the EU15 average of Makerspaces present on the territory is 50.6 per country, while in the EU28the average is 29.5. The research investigated also the Makerspaces history in a temporal perspective, starting from 2000, when the first Makerspaces arose along Europe. According to the data, the increasing trend started in the 2007, and from this year Makerspaces continually increased in terms of number until 2013.

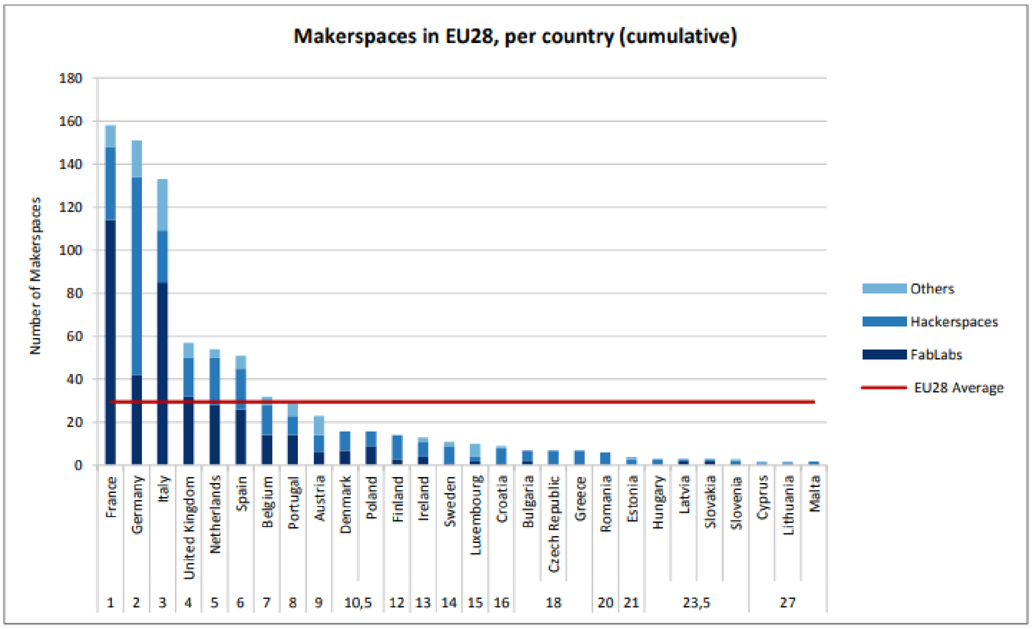
Figure 4. Geographic location of the Makerspaces in EU28 superimposed to the population density



Source: Rosa et al., 2017

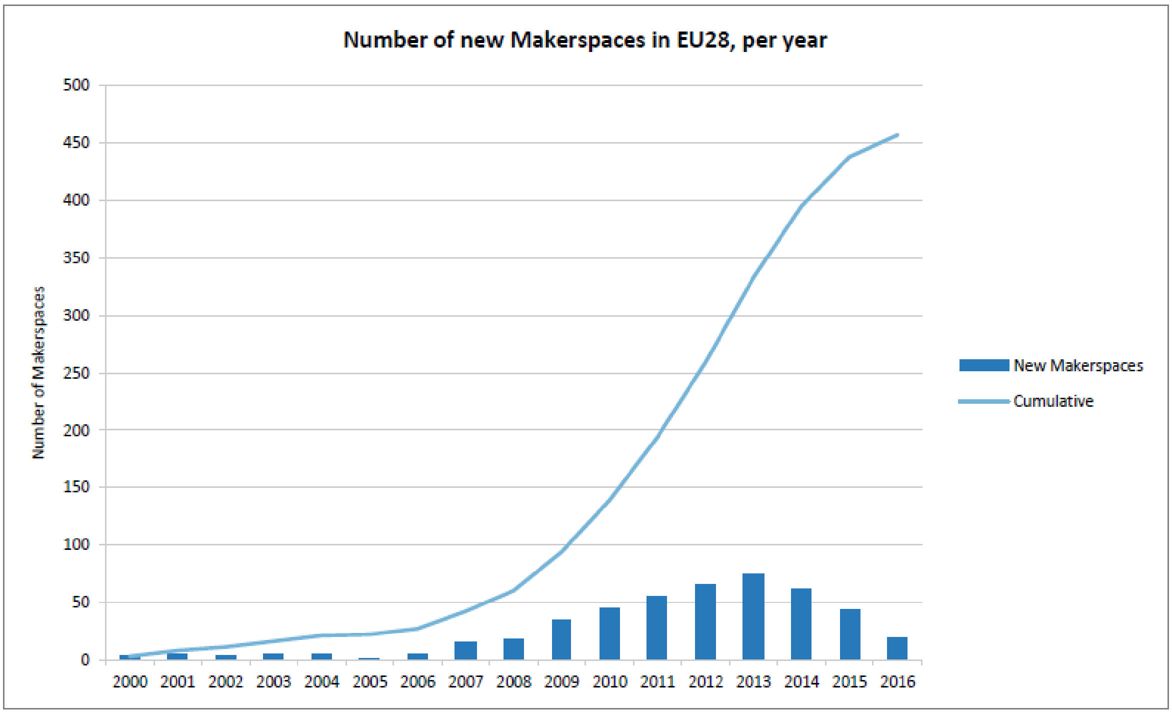
Even if cumulative number is steadily increasing, from 2014 to 2016 it seems that the number of new Makerspaces steadily decreased to the numbers of 2008.

Figure 5. Total number of Makerspaces in EUR28, listed by country and typology (cumulative)



Source: Rosa et al., 2017

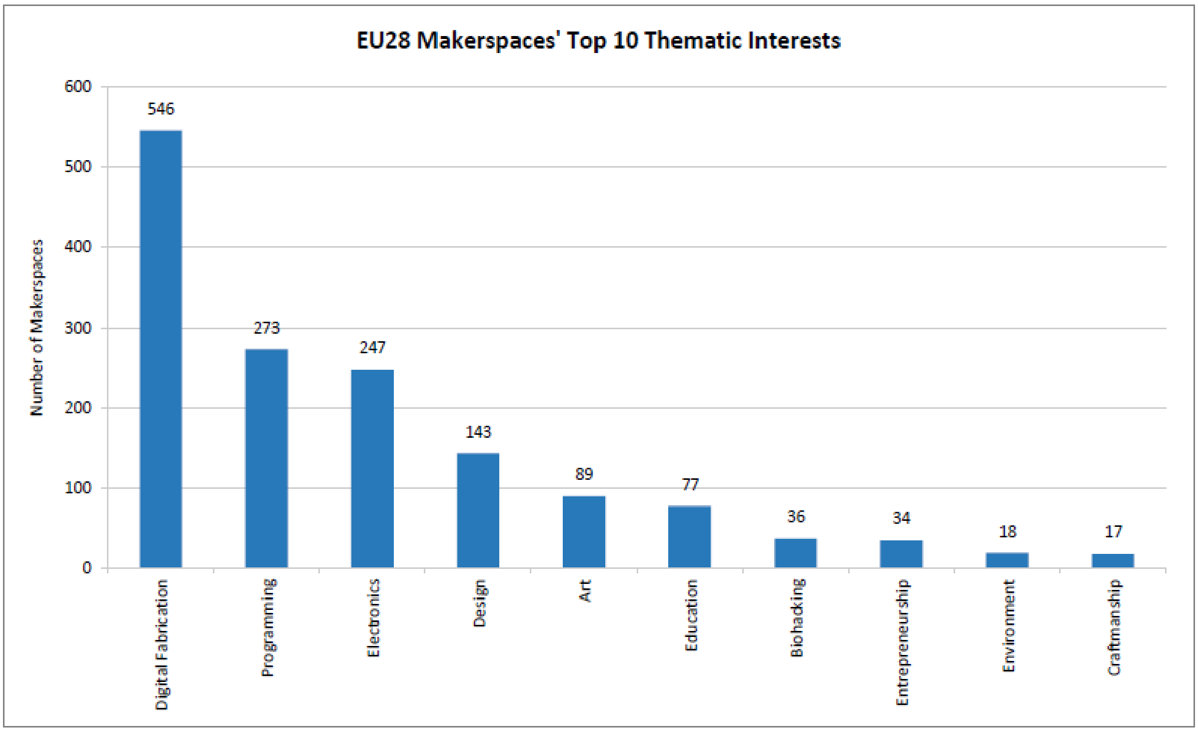
Figure 6. Evolution of the number of Makerspaces in EU28, per year



Source: Rosa et al., 2017

Looking at the **Figure 6.** illustrating the cumulated number of Makerspaces per year, it is possible to see the formation of a saturation curve for the years of 2015/2016. This is probably due to the fact that, as the number of Makerspaces increases in a country, the demand for additional, new ones is decreasing, showing a saturation trend: if several Makerspaces exist in a city or nearby, there could be no further need to create another makerspace within the same sphere of influence.

Figure 7. Top 10 main interests of the Makerspaces in EU28

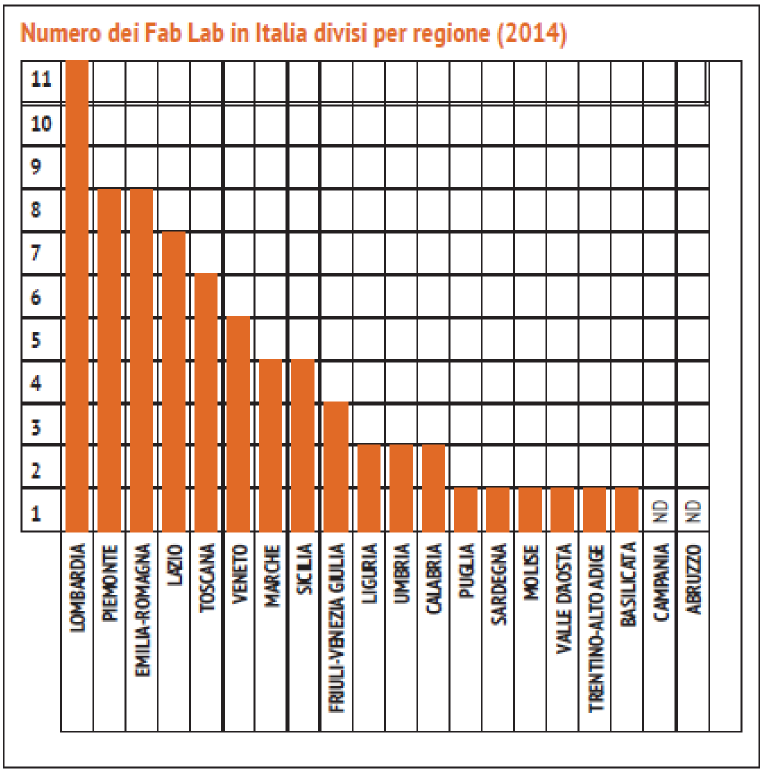


Source: Rosa et al., 2017

The survey investigated also the thematic interests shown inside the Makerspaces from their members (**Figure 7**.). It is observed that the main thematic areas of interests are very similar among the various spaces: 546 Makerspaces indicated interest in digital fabrication, 273 in programming and 243 in electronics. There were frequent mentioned also topics related to design, art, education, environment and craftsmanship. It was shown how the list of equipment declared to be available in Makerspaces reflects the interest of the various spaces, with digital fabrication tools having a prominent role: 3D printers, laser cutters and CNC milling machines are the most cited machinery, with 557 Makerspaces declaring to have at least one 3D printer, 389 Makerspaces at least one laser cutter, and 373 Makerspaces at least one CNC milling machine. The research present also the detailed results of the inquiries divided by Country.

In the **Figure 9.** is presented the Italian situation analysed in 2016. Italy is positioned at the third place in the European Union for numbers of Makerspaces, that are 133 in the whole country. Looking at the typology, there are 85 Fab Labs, 24 Hackerspaces and 24 other typologies of Makerspaces that all together represent the 16.1 % of the Makerspaces in the UE. The main interests of those Makerspaces are Digital Fabrication, Electronics and Design. Makerspaces are distributed all over the country, with a prominence in the North and an important presence in the Centre. Maker Movement get a foothold in Italy where starting from 2013 in Rome there is one of the most important Maker Fair in Europe, and the number of FabLabs is constantly increasing. Italy is a country of smart artisans and inventors, entrepreneurs that are able to connect precision mechanics with design as no one else in the world (Toschi et al., 2018). Italian Maker Movement is strictly connected with the Made in Italy concept, that summarize all the creativity, innovative, design characteristics of the Italian artisans and entrepreneurs that are known for their excellence all over the world. FabLabs diffusion in Italy can be attributable in part to the expansion of the Maker Movement, and in part to the intrinsic characteristics of the educational path of the country and its manufacturing history. A research from Fondazione Nord Est in collaboration with Prometeia (2015) shows two different strategies observable in the Italian Maker Environment: some FabLabs arise as direct involvement of Makers that have socialization and commonality aims and are interested in digital manufactory literacy among themselves and other members of the local community, other FabLabs are stable interlocutors for the relationship with companies and formal entrepreneurs. The same research shows the regional distribution of the Makerspaces in Italy, quantified in **Figure 8**. The first region in terms of quantity is Lombardy, followed by Piemonte, Emilia Romagna, Lazio, Toscana and Veneto.

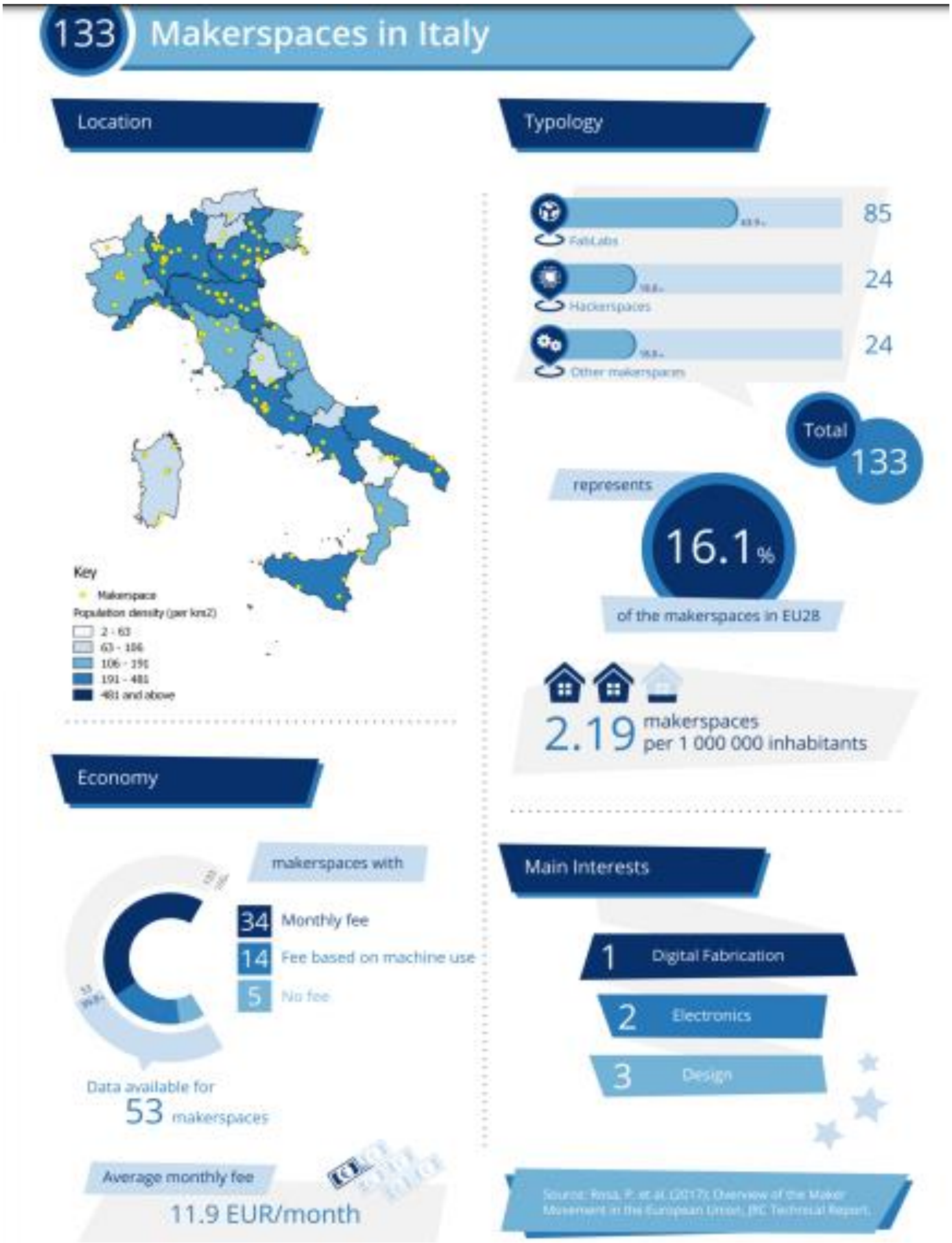
Figure 8. Number of FabLabs in Italy divided by region



Source: Fondazione Nord Est e Prometeia, 2015

Made in Italy is an important asset of the Italian cultural and entrepreneurial environment, that suffered from digitalization and introduction of new technologies, especially for those little realities that become unconnected with the global economic world, and strived to find in globalization an opportunity for relaunching from the crisis. Inside the Maker Communities there is the right balanced environment that connect creativity, innovation and handwork with the new digital fabrication tools. Digital revolution can be either a condemnation and an opportunity: the difference stems in the cultural preparation and education of both passionate and especially entrepreneurs, that can suffer from it or ride it. FabLabs potentials need to be explored and investigated, since they can imply the creation of substantial value if connected with manufacturing enterprises. Some examples of collaboration between Labs and enterprises shows how fundamental are those spaces in order to foster innovation following the market trends and being at the right time to respond at market demands. Deutsche Telecom established T-Labs, with the aim of engage users in problem-solving process and in R&D activities.

Figure 9. Makerspaces in Italy



Source: Fondazione Nord Est e Prometeia, 2015

In 2004, the University of Berlin (TU Berlin) and Deutsche Telekom came together to found the university-affiliated institute Telekom Innovation Laboratories (T-Labs). The object of their partnership is to realize joint research in information, communication technologies and digital innovation. The scientific discoveries by the Lab contributed to the development of new products and solution optimization at Deutsche Telekom. They understood the importance of sharing and working together in order to realize various projects and find different solutions that the company itself alone couldn't have reach. An Italian example is the D&MC-Lan in Vigevano. The Design and Mass Customization Laboratory as born in 2002 with the object to execute R&D activities on the new productive paradigm of the Mass Customization, in particular in the footwear sector. The Lab is composed by four distinct Operating Units: 1) Scientific research activities 2) Technical activities, in the specific the maintenance of the infrastructures 3) Manufacturing activities, and experimental projects 4) Learning activities.

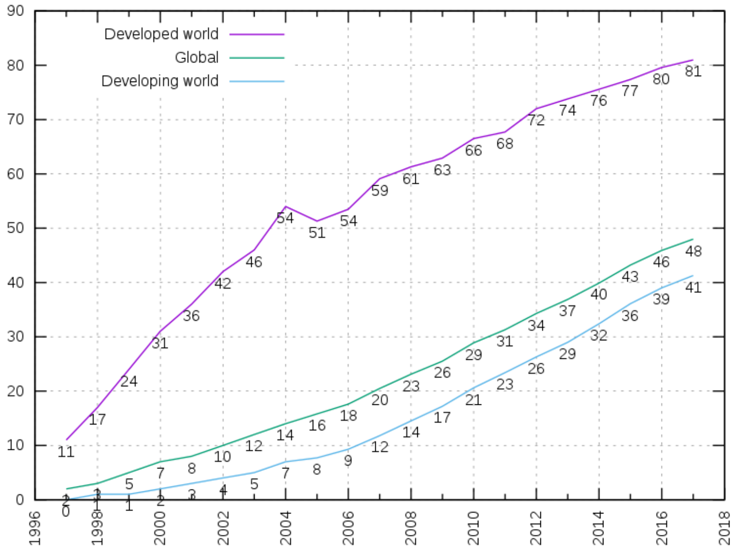
Maker communities and spaces, and the social movement around them, can be an unprecedented opportunity for both big and small manufacturing enterprises, by addressing to a wide range of interests and motivation levels. FabLabs are capable of encouraging people from different backgrounds and create learning environments in which new ideas arise in a totally, new, innovative, multicultural path. In the context of the Maker Movement, emerge a new Makerspace environment that is requiring new models of education, collaborative work and manufacture. These spaces have primary a multidisciplinary learning role, in which the stimulation of new ideas and concepts for products is enhanced, allowing an environment that fosters invention and design cycles. This is specifically due to i) the digital fabrication technologies (3D printers, laser cutters, CNC milling machines) available at these spaces, and ii) the collective knowledge of the maker community (Rosa et al., 2017). The accessibility and affordability of personal fabrication technologies renders everyone potential producers, introducing a decentralised and highly customised manufacture model. In this new manufacture model, a shift in the nature of the producer is quite inevitable. Makers – that are not already professionals – are increasingly becoming entrepreneurs, leading the development of rapid prototyping 3D printers, autonomous robots, and other digital smart devices. Indeed, a number of successful companies (worldwide) already emerged from these spaces and potentially infinite ones can arise from zero or relaunch from crisis by adopting those paths and by introducing Labs and Communities connected with their industry.

1.3 Web 2.0

Talking about digital revolution and democratization of new technologies, it is mandatory to introduce the concept of Internet and the evolution that the market and the industries are going through. By the adoption of Web 2.0 technologies and tools, companies are increasingly involving users in the process of creating new products.

Within 15 years the Web has grown from a group work tool for scientists at CERN into a global information space with more than a billion users. Currently, it is both returning to its roots as a read/write tool and also entering a new, more social and participatory phase. These trends have led to a feeling that the Web is entering a ‘second phase’—a new, ‘improved’ Web version 2.0 (Anderson, 2007). The fact that customers can play an active role by using the multiple tools made available to the platforms, sharing opinions, creating post, participating with its own content shows how the revolutions in the digital environment are affecting the world of companies at all levels.

Figure 10. Internet users per 100 inhabitants



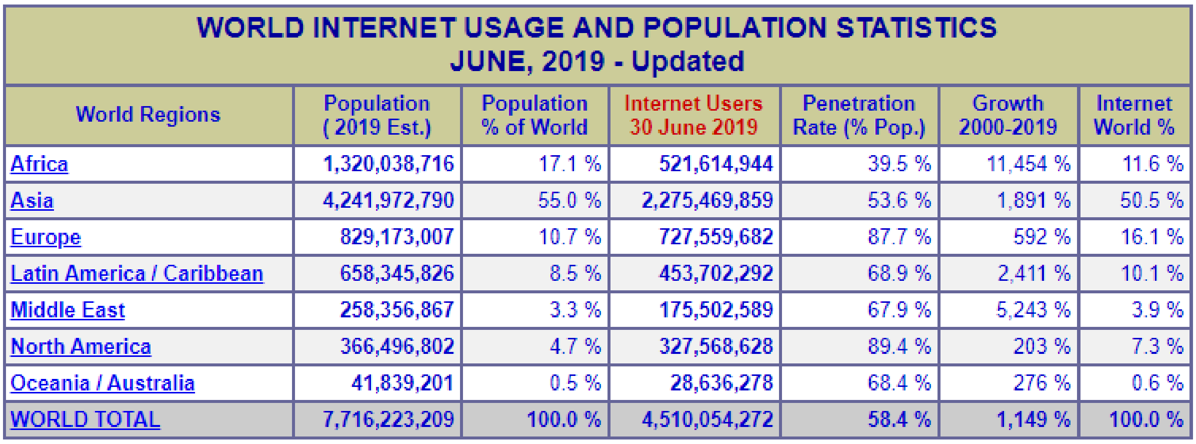
Source: International Telecommunications Union, 2018.

Figure 10., by the International Telecommunications Union (2018), shows the data about internet users per 100 inhabitants in the World. There is a quite important discrepancy between the developed world and the developing one, thus influencing the global mean. What is clear about the data is the unconfutable upward trending, starting from the end of the ‘90s, where just a little percentage of population adopted internet tools. Today (data are adjourned at 2018), Developed countries register 81 Internet users per 100 inhabitants, while Developing countries 41. The global mean is 48 Internet users per 100 inhabitants.

A further research from Internet World Stats show data updated at June 2019 regarding Internet spreading throughout the world, analysed in the different continents (**Table 1**.). Globally, there are 4.5 billion Internet users in the world as at June 2019, for a population of 7.7 billion people. This is compared to 3.9 billion Internet users in mid-2018 and about 3.7 billion Internet users in late 2017. The global compounded growth rate in the period 2000-2019 is 1,15%. Asia has the most Internet users of all continents – accounting for 50.5 % of all Internet users (stable from about 50 percent in 2017 and up from about 48 percent mid 2018). Europe is a runner up with 16.1% of all Internet users, followed by Africa and Latin America. By weighting these data according to population, i.e. number of inhabitants, the result is that North America, followed by Europe, have the higher penetration rate – accounting respectively for the 89.4% of the population in NA and 87,7% of the population in EU.

A study carried out by TNS, a company that deals with market research and marketing, argues that the Internet is at the forefront of global level the first media channel for network users: 61% of the Worldwide users, use it daily, compared to 54% using TV, 36% the radio, 32% the press (2010). In addition to be a highly popular digital medium, especially in developed countries, it represents a source of advantage for companies and their communication, both internal and external, because it constitutes a direct window to the daily life of customers, and it allows a dual-relationship with commutative exchange of information.

Table 1. World internet usage and population statistics



WORLD INTERNET USAGE AND POPULATION STATISTICS
JUNE, 2019 - Updated

World Regions	Population (2019 Est.)	Population % of World	Internet Users 30 June 2019	Penetration Rate (% Pop.)	Growth 2000-2019	Internet World %
Africa	1,320,038,716	17.1 %	521,614,944	39.5 %	11,454 %	11.6 %
Asia	4,241,972,790	55.0 %	2,275,469,859	53.6 %	1,891 %	50.5 %
Europe	829,173,007	10.7 %	727,559,682	87.7 %	592 %	16.1 %
Latin America / Caribbean	658,345,826	8.5 %	453,702,292	68.9 %	2,411 %	10.1 %
Middle East	258,356,867	3.3 %	175,502,589	67.9 %	5,243 %	3.9 %
North America	366,496,802	4.7 %	327,568,628	89.4 %	203 %	7.3 %
Oceania / Australia	41,839,201	0.5 %	28,636,278	68.4 %	276 %	0.6 %
WORLD TOTAL	7,716,223,209	100.0 %	4,510,054,272	58.4 %	1,149 %	100.0 %

Source: www.internetworldstats.com, 2019

Web 2. 0 is considered to be the network of platforms and dissemination of connected devices that ensure costless and rapid full data sharing. The term Web 2. 0 was officially coined in 2004, at a conference during a brainstorming session about the future potential of the Web, when Dale Dougherty, the founder of Make magazine, the creator of Maker Faire, and the cofounder of O’Reilly Media, along with O'Reilly, wanted to capture the feeling that despite the dot-com boom and subsequent bust, the Web was more important than ever, with exciting new applications and sites popping up with surprising regularity (O'Reilly, 2007). For many companies, the ability to access Internet and share the information and knowledge in the world wide web constitute a turning point. The web is a platform that guarantees access to a plurality of sites by means of a network that involves a large number of companies and applications. To underline the transition from web 1. 0 to web 2. 0, O'Reilly (2007) compares programs and applications that have characterized the transition between the old and the new paradigm. The most emblematic is what sees as the protagonist Google, born as an application web provided to customers as a service paid for directly or indirectly by users. Web 2.0 allows to have access to a virtual work force that was unreachable in the past, and as a matter of fact, applications like Wikipedia.org, Flickr, YouTube, Facebook, and Del.icio.us, represent an invaluable media source which is easy to use, cheap, interactive and decentralized. One simple characteristic of

Web 2.0 is that it does not impose any notion on how the work has to be done and there is no predefined knowledge structure: it leads to flexibility and a user-centric system.
According to Constantinides (2008), Web 2.0 is a collection of open-source, interactive and user-controlled online applications expanding the experiences, knowledge and market power of the users as participants in business and social processes. Web 2.0 applications support the creation of informal users' networks facilitating the flow of ideas and knowledge by allowing the efficient generation, dissemination, sharing and editing/refining of informational content. Web 2.0 represents for businesses new challenges but also new opportunities for getting and staying in touch with their markets, learning about the needs and opinions of their customers as well as interacting with them in a direct and personalised way.

The key innovative elements typifying this new family of web applications can be summarised in three main principles:

1. Focus on service-based, simple and open-source solutions in the form of online applications.
2. Continuous and incremental application development requiring the participation and interaction of users in new ways: not only ‘consuming’ but also contributing, reviewing and editing content.
3. New service-based business models and new opportunities for reaching small individual customers with low-volume products.

Among Web 2.0 tools we can distinguish someone that fosters collaboration between companies and customers, thus facilitating the interaction. The online world has approached to Web 2.0 implementing user empowerment and user generated content. Thanks to these technologies, the corporate strategy of many firms has changed, including programs such as open source, crowdsourcing and mass customization. In the next lines we will analyse more in detail some of the Web 2.0 tools, explaining in which way they can benefit both firms and customers in their mutual relationship, ending with the creation of value introduced in the paragraph regarding co-creation and co-production.

1.3.1 Communities of Users

> *Man is by nature a social animal; [...]. Society is something that precedes the individual. Anyone who either cannot lead the common life or is so self-sufficient as not to need to, and therefore does not partake of society, is either a beast or a god.*
>
> Aristotle, Politics

Online communication technologies are enhancing the emergence of novel forms of social communities, often referred as virtual communities, or communities of users, with the ability to engage customers in an on-going dialogue with other customers and also with the firm. Thus, leveraging a customer-based value creation system by providing a way to interact, learn, conduct transactions and share valuable knowledge with all the parties involved in the development and usage of products and services. Virtual communities *are groups of people who use communication technologies for repeated social interaction to meet certain needs* (Preece, 2000).

Most of the online community members share the same interests and experiences. They get together in order to chat online, exchange personal experiences and post news about their products and services, so they can learn from others' experiences and acquire information for buying decision-making. In this scenario, organisations have realised the tremendous business co-creation and co-innovation value and benefits that communities can bring to business processes such as product design, marketing, branding and innovation process. The community and in particular the web-based community gives the company the ability to develop and pursue innovative activities involving a large number of number of actors who can contribute actively and voluntarily to the process of developing a new product. Online customer communities' participation in product development facilitates proactive learning about the customer and leads to better understanding and anticipation of latent customer needs (Romero, 2011). Customers are coming together in online communities where they are publishing and sharing their experiences with products and services, and therefore evaluating the effectiveness of their producers, vendors and service providers.

The organization of communities is usually characterized by free access, which allows all interested parties to intervene with their suggestions and opinions through forums and blogs in order to feel like members of a wide and dynamic network. Communities of users and of developers allows to develop and implement open source projects between companies and users. The quality of collaboration in the community is crucial for any software project.

For a good and effective use of the community, transparency and trust between the company and the users are essential in order to guarantee an exchange of information and a form of constructive collaboration to the advantage of both parties involved. Specifically, trust is presented as a mechanism for controlling exchanges between the actors of the network that comes to create (Molina & Morales, 2010). Usually members of each community are connected and assist each other via computer mediated communication tools (e.g., wikis, forums), as well as via real world meetings (e.g., Maker events, Hacker-spaces).

According to a 2014 TNS study, listening to the connected prosumer Social media has a strong influence on consumer behaviour and brand commitment: 57% of online consumers write comments about products or brands (they were 47% in 2011), 70% of online consumers forward contents about products or brands; 77% ask a question to a brand online, 86% agree that reading comments/reviews on brands made by other people helps them make quick and easy decisions about products or brands.

Tormod Askildsen, manager of LEGO New Business Development, state that "monitor blogs and reactions in the various communities is always a good indication of whether there is a viable market segment out there." Lego is the company that allows for the most makers satellites start-ups made by their fan, for example BriksArms, a company that offers toy-compatible custom weapons & weapons packs for Lego toys. Lego, historically, refused to build weapons kits in accordance to its mission and values. This external companies of passionate users who started to commercialize Lego compatible weapons are benefiting Lego two ways: first, because they are allowing Lego to maintain a niche target by satisfying their need, second because at the same time it allows Lego to remain truthful to its core values that are against war and weapons. This is a simple and significative example of how users' communities and makers can create value around a central company without penalizing anyone, but just reaching more niched customers.

Among the strengths of the open communities we find the collaborative spirit, the absence of policies of protection and monopoly of intellectual property by means of copyright and patents, and the lack of incentives, especially of an economic nature, which allow for all stakeholders to develop their own innovation starting from what has been introduced by others, avoiding inefficiencies, the redundancy of resources used and the need to do something that has already been done by others. Prandelli, Verona and Sawhney (2008) also identify some elements that a virtual community must do in order to have a positive role for the company:

- Aggregate the demand on a global scale, and in this it is facilitated by the possibility given by the exploitation of web tools, that go beyond the nearby territory alone;

- Implement market research in order to better understand consumer needs. In general, these market research studies are conducted within the communities of interest where members share a passion;
- Identify the flow of communication with and between customers and manage the “word of Mouth” inside and outside the community,
- co-define the values associated with the brand: the customer must strengthen the image of the company by identifying with the brand in order to expand the virtual environment;
- Provide fidelity and guarantee of continuity.

Among the different participants within the communities, how to identify those who can bring more value-creation to the company? In 2009, Marchi and Bordoni made a research that aims to define models that, starting from large and heterogeneous populations of community participants, classify and select the consumers that can potentially considered most interesting for their ability to collaborate in innovation. One of the key points on which their theory is based concerns the customer's knowledge of the product. The customer's ability to collaborate in the business innovation process and to generate new ideas and solutions for the product depends closely on the knowledge he has about the product itself. Identifying the cognitive endowments of participants in a virtual community is a very complex task, given the difficulty in developing deep and direct communicative relationships with each of them. Better selection supports the ability to engage innovative customers in new product development teams and other activities useful for the development and launch of new products. The concept of innovative customer that has found the greatest degree of consensus in the literature is that of lead users (Von Hippel), defined as those customers who, strongly encouraged to participate in the process of innovation for the pursuit of an economic benefit and not, thanks to practical experience in the use of the product and the ability of prospective analysis, are able to represent the need for an innovative product ahead of the rest of the market. Only consumers who have *the real-world experience needed to problem solve and provide accurate data to inquiring market researchers* (Von Hippel) can aim to contribute to product innovation. The company must manage the user communities in such a way as to create language interpretation algorithms or systems that allow it to identify, among many, those who have more experience, product knowledge and personal skills - the lead users. At the same time, those who actively participate in the community not only for passion reasons, can experience a broaden set of benefits derived from their participation inside the community, starting with the increase in the function of utility, also linked to the possibility of a better understanding of the product and therefore optimization of its use. Other reasons concern the acquisition of information and therefore the possibility to access a variety of knowledge relating to the interest that is the basis of the birth of the community, benefits related to social integration and the possibility of customers to interact with each other. Other reasons regard personal benefits, linked to the increase in credibility and self-esteem of those who interact in the community as well as the opportunity to live pleasant and stimulating experiences.

Online communities represent one of the most important and meaningful Web 2.0 tools for customers-companies' collaboration for product innovation. Examples of communities can be seen everywhere, every time a group of person sharing the same passion or needs meet together in those virtual spaces, often building a community around a company or a single product; when those communities have, among their objective, the one to share experiences about possible modifications, updates, realization of objects, those communities fall into the definition of Makers' Communities.

Maker Communities. In its Maker Movement definition, Anderson (2012) determined the second criteria as the creation of a cultural environment that foster collaboration and sharing within online communities. The sharing principle is a recurring concept when referring about Makers and DIY movement, as well as collaboration. Makers communities respond to the open source principle of sharing by showing a unique approach to collaboration and community maintenance. A community is formally defined as a group of people who share common goals and interests by communicating through mediums online and in person (Chorianopoulos, Jaccheri & Nossum, 2012). According to Marchi and Bordoni (2009) communities are places – that can be virtual or physical – in which consumers interact among each other by sharing knowledge about products: the interaction allows them to socialize inside the community and to share knowledge and common understandings. Diffusion of communities has been favoured by the spread of the online communication technologies: with Internet all the people that shared the same interests in the same fields all over the world had the possibility to create virtual spaces in which they could talk, share ideas, comments, post photos, videos, ask for something. Online communities generate interest among researchers because of their magnitude: they can bring new ideas, solutions and diversified knowledge that is useful to firms, even if there is no direct interaction and communication between users and the firm itself. Another important aspect of online communities is the fact that it fosters innovation because it allows participation of people with different background and different cultures, in a multidirectional collaboration that can investigate the same problem from different perspectives and thus to obtain diversified solutions. The online communities' origins dates back to the end of '80, when from the idea of Stewart Brand and Larry Brilliant, was born the first online community in the history called The Well (Whole Electronic Link), a free online space in which people could participate in public debates through videoconferences, but also share messages and opinions in the forum and by emails. Howard Rheingol, an American journalist expert in multimedia communication, after being involved with The Well, wrote a book in which he defined the new concept of virtual communities and the new platform experience:

Virtual communities are social aggregations that emerge from the Net when enough people carry on those public discussions long enough, with sufficient human feeling, to form webs of personal relationships in cyberspace (Rheingold, 1994).

Reighnold, in his definition, underlines the social aspects that characterize the phenomenon:

- An adequate number of participants: in order to let the community works it is necessary that the people involved are *enough.* This means that there is a minimum number of users that make attractive the developing of the relationship. Below this number people are not motivated to participate in the community. It is also true that virtual community are favoured by the Net, that allows aggregation of more and more people without location boundaries.
- A permanent membership: Virtual communities' members need to participate to public discussions *long enough*, this means that occasional contributions are not sufficient to constitute a real network. The more users participated for long time in a community, the most successful it is likely to be and the strongest the relationship could have been established.
- A sense of belonging: members should be active participators, that implies sharing their *human feelings*, starting to feel part of something, in which they can identify and express themselves. The relationship between participants can lead to both technical and personal interactions, since the sharing of information has no boundaries: it can be extended to every argument.

Another aspect that can be relevant to the establishment of a community is for example the importance of reputation: since the focal point of the platform is to collaborate and share information, mutual respect and reciprocal understanding is fundamental. Also considering that the communication takes place only by a computer interface, that limits the physical perception of the counterpart, the only way to establish trust between participants is by virtual experience: each user must concur in the definition of shared norms and values that everyone should respect, and recognize if someone deviates from the established norms and loose its reputation.

Ebner, Leimster and Kremar (2009) define the community members as people who interact socially as they strive to satisfy their own needs. These people share purpose, such as an interest, need, information exchange or service that provides a reason for the community. Policies, in the form of tacit assumptions, rituals, protocols, rules and laws that guide social interactions. Communities on-line use computer systems, to support and mediate social interaction and facilitate a sense of togetherness.

The evolution of virtual communities, with the spread of Industry 4.0, can be recognized in the arise of Communities of Makers. The term “Maker Community” describes a community built around an emerging democratized technology, such as 3-D printing, Internet of Things and tools like Arduino, that connects users and amateurs in a collaboration process that has the purpose to create, share and modify real objects by working on digital designs and engaging in activities from crocheting and design to robotics and auto repair (Morreale, Moro, Chamberlain, Benford & McPherson, 2017). Even if there is no large-scale study of online Maker Communities, or DIY Communities, in the following lines we will try to define the phenomenon and fix some specific characteristics that distinguish a Maker Community from any other virtual community. The reasons why some researchers have been profoundly interested in understanding the Maker Movement are connected to some focal points: this is a technology-based force that due to its democratization allows to empower customers (Morreale et al., 2017); this is a new way to conceive innovation and customers’ demand; this is a phenomenon most of the time not driven by economic reasons but it is able to create significant value. Maker communities are online platforms on which users can upload products designs or share new ideas through Web 2.0 instruments like blogs, forum, social networks. Usually it includes people from different backgrounds and technical knowledge, with no access restrictions, thus implying a valuable source of information and ideas for companies that are searching for a feedback from the market. It is important to understand how significant communities are for companies: usually companies strive to collect information from their target market and sometimes it can be an effort in terms of time and costs even to identify and delineate their target market. By gathering information from communities, companies are directly communicating with their most loyal customers at the right time and with potentially zero costs. Maker communities can be considered as a natural aggregation of customers that socially interact and argument about a specific product or a specific firm, and they can be the basis on which companies can start innovation processes and generation of new ideas. Makers communities are experiencing a broader participation of non- technical users in the engineering of interactive system. Besides online sharing, people join communities for various purposes (Chorianopoulos et al., 2012). The ideal participant is someone very passionate, that works in a completely different field, and spend time on the community when he’s out of work; usually he has personal motivation or a problem to solve – this happens especially in the healthcare sector, when parents or people are searching for particular solutions not yet implemented in the market. The skills and motivations of Maker communities are broad. Most of the time software developed by makers and for makers results in an intersection between software and art. Artists need software technology for creating and evolving their artwork. At the same time technologists look at the contact with artists as a source of inspiration for innovation (Chorianopoulos et al., 2017). Due to the diversified background of community users, it is important to establish a common language that allows interaction. For the same reason it is most likely that not all the participants will be interested in the same aspect of the products so that they will "speak different languages": for example, the one interested in the design are interacting with different terms in respect to the ones that are interested in the technical characteristics of the product, especially for those products that are highly technological. Marchi and Bordoni (2009) investigates users inside virtual communities and their background by collecting the language they utilize when posting on the community. According to their thesis, a company should create tools that are able to analyse users posts and comments in the community webpages, and by differentiating them on the basis of terms that they utilize – more specific and technical ones or more generic one – identify those users that are most valuable for a collaboration: those that are able to give better ideas, those that have a deep knowledge of the product and the technology inside the product and those one that possess higher cognitive abilities. They can be defined as Lead Users, following Von Hippel definition (1986), those customers that have high incentives to participate in the innovation process due to the fact that they will benefit from it. They usually have a long experience with the product and a deep understanding of its functionality, and this is the reason why they are able to identify the improvement required for the product before the market does. What Marchi founded is that usually Lead users have some fixed characteristics: since they have a deeper understanding of the product, their contributions in terms of number of interactions on the community will be several ones. Furthermore, due to their knowledge, Lead users will post comments with a technical content in respect to other users and will be more likely to express critical opinions. This discrepancy in users' background inside a web community allows Makers platforms to become a learning environment: what Ito (2013) defined as Connected learning:

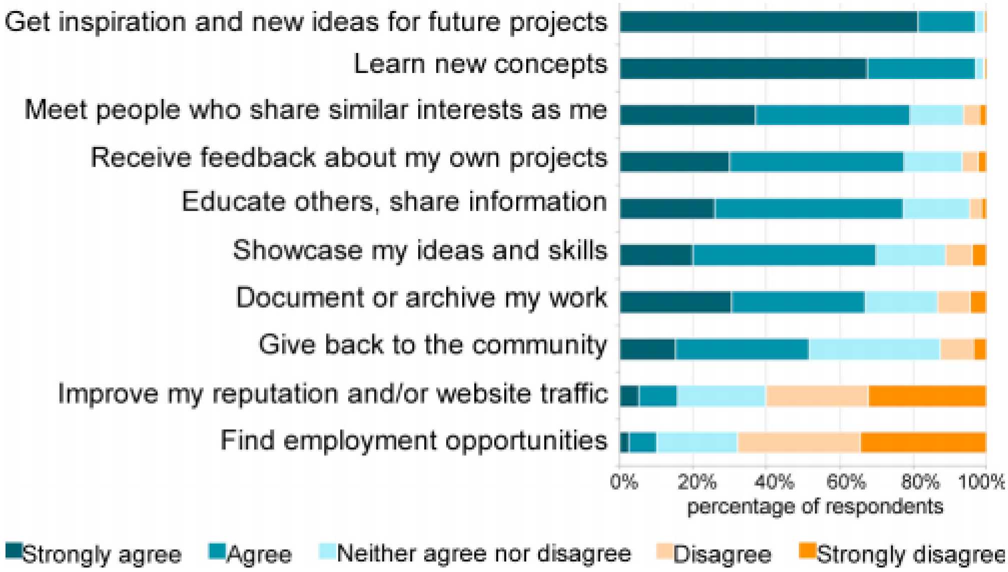
> Connected learning is realized when a young person pursues a personal interest or passion with the support of friends and caring adults and is in turn able to link this learning and interest to academic achievement, career possibilities, or civic engagement. Digital and networked media offer new ways of expanding the reach and accessibility of connected learning, so it is not just privileged youth who have these opportunities. Connected learning looks to digital media and

> communications to: 1) offer engaging formats for interactivity and self-expression, 2) lower barriers to access for knowledge and information, 3) provide social supports for learning through social media and online affinity groups, and 4) link a broader and more diverse range of culture, knowledge, and expertise to educational opportunity.

Connected learning definition identifies the opportunities that digital media provides to users, by connecting home, school, communities and peer contexts of learning, supporting intergenerational connections based on shared interests and passion-driven knowledge. Everyone in a community is offering some knowledge without asking for a recognition, because in the framework of communities the provision of knowledge is common habit, and the resulting learning is intrinsic in the basic rules of the platform. Connected learning is based on three core values: equity, full participation, and social connection. Full participation entails community learning environments by encouraging members' active engagement and participation. An essential role is given to the social connection, because learning is more meaningful when it is part of a person's valued social relationships and shared practices, culture, and identity. The learning principles that drive the core values are based on interactive and networked web media which make learning and digital product ideation interest-powered, peer-supported, and academically oriented (Morreale et al., 2017). Openly networked web-based communities provide opportunities for learners of all ages who share a common interest to come together to produce, circulate, curate, and comment on media. *Learning comes from actively creating, making, producing, experimenting, remixing, decoding, and designing, fostering skills and dispositions for lifelong learning and productive contributions to today's rapidly changing work and political conditions.* (Ito et al., 2013) This is important not only for the connected learning that emerge among participants but also considering how this diversified learning can benefit the external firm by giving knowledge that is almost impossible to develop inside the R&D departments, because what is missing is the versatility and the diversity of viewpoints that can for sure show new firm's opportunities for change and improvement.

But what fosters community sustainability and what motivates participants besides connected learning? We already assumed that connected learning comes from the critical role participants have, given their diversified background and skills, that allows to transfer various ideas across community and built a shared-learning environment. But community sustainability mostly depends on the spontaneous involvement and participation by its members that are active even when the initial input from the developer reduces or vanishes (Morreale et al. 2017). The active, permanent, motivated participation is a milestone in the success of a web community. The participation allows members to affirm their need for self-actualization, to get inspiration for future projects and to receive feedbacks on personal projects from a diversified audience (Kuznetsov & Paulos, 2010).

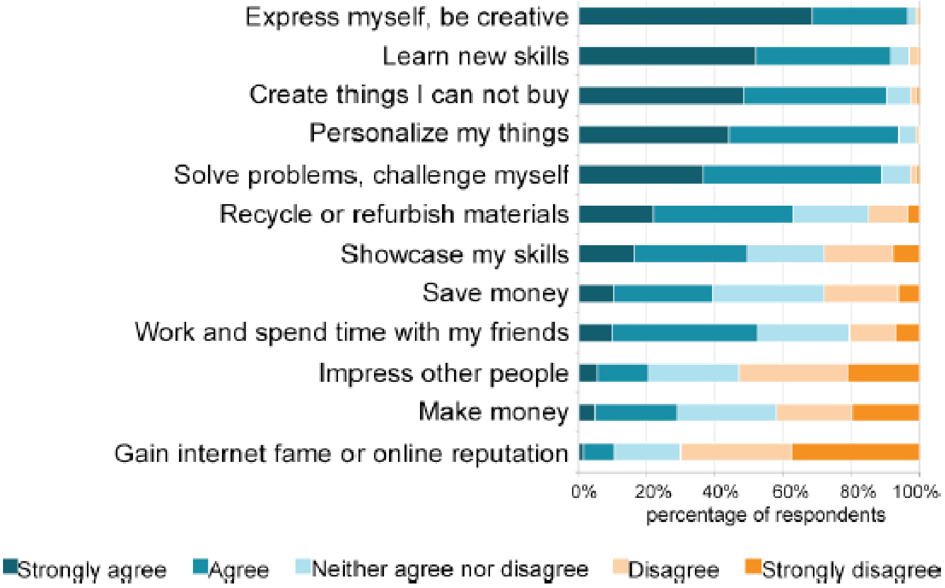
Figure 11. Motivation for contributing to DIY communities



Source: Kuznetsov & Paulos, 2010

A study from Kuznetsov and Paulos, based on the results of an online survey submitted to 2608 respondent aged from 18 to 95 belonging to six of the major DIY communities (Instructables, Darkbot, Adafruit, Raverly, Craftster, Etsy), revealed the motivations why people contributes in online communities (**Figure 11**.). Above all else, participants contribute in DIY communities to get inspiration and new ideas for future projects and to learn new concepts. The third motivation is about social relationship: members have in Makers' Communities the opportunity to meet people that share the same interests as they. They also highlight motivations regarding information exchange like receiving feedbacks about their projects and educate others, share information. Surprisingly giving back to the community and built a reputation are the third and second least supported, even if some experts recognize in reputation and community contribution some of the focal point of the maker communities. The last motivation, supported also by the theory, is about finding employment opportunities. Evidence shows that economic reasons are not contemplated in the DIY community's paradigm because are in contrast with the real motivations of participants. *A large portion of free responses emphasizes fun as a motivation: "have fun!" or "it's fun!" Other comments revolve around learning, for instance: "to learn new techniques", and community bonds: to "socialize" or "to feel connected to other like-minded people"* (Kuznetsov et al., 2010). Motivations for contributing to DIY communities highlight information exchange as a core value: receiving feedback on projects, educating others, and showcasing personal ideas and skills are the top factors. Sharing is accessible to individuals of nearly any background, since lack of equipment or skill is not a significant barrier.

Figure 12. Motivations for contributing to DIY projects



Source: Kuznetsov & Paulos, 2010

Furthermore, the study explores the motivations why members contribute to DIY projects (**Figure 12**.). Here emerges clearly the creative energy that characterize makers: nearly the totality of respondents (97%) identifies to be creative and express their self as the main motivation for participating in DIY projects. Learn new skills is the second reason: here again the concept of connected leaning is reflected by the evidence. Other motivations are related to personal needs of the specific participants, like create things they cannot buy – because they cannot afford or because they are not in the market yet – personalize their things and solve problems. The least popular reasons also there, are about economic drivers and reputational aims. DIY communities lower the barrier to entry into different projects and initiatives, by enabling what one respondent describes as "exchange of ideas with so many different persons with different technical, artistic and professional backgrounds”. DIY communities thus invite individuals across all backgrounds and skill levels to contribute, resulting in: 1) rapid interdisciplinary skill building as people contribute and pollinate ideas across communities and 2) increased participation supported by informal (“anything goes”) contributions such a comments, questions and answers. From a closer inspection to the research can emerge how motivations of DIY participants are closely related to the highest needs in the Maslow’s hierarchy of needs (1954): Belongingness needs – and the necessity to identify themselves with people that shares the same interests and passions, and be part of a group that, for example, utilizes the same jargon as language and share specifics rituals or habits; Esteem needs – even if the cited research poses the reputation at the last levels, usually community members are searching for feedbacks from other members, and they would accept constructive critics but they also feel better when someone recognize they made a good job; Self -actualization need – strongly connected with creativity and passion, DIY community members are looking for a place in which they are free to express themselves and their ideas, find people that understand them and finally to realize their project and be useful for others.

Looking at some cases of Makers’ Community can give us an idea of the magnitude of the phenomenon and figure out what possible development could emerge and what are the social and economic opportunities connected with the diffusion of communities.

One of the earliest “modern era” DIY communities raised among amateur radio hobbyists in the 1920’s. These hobbyists relied on amateur handbooks and shared among each other imagination and open mind principles along with technical aspects of radio communication. They used to meet in person to discuss their work as w person to discuss their work as well as unrelated social subjects. They continue to exist during World War II, even if a ban was placed on amateur radio communication (Kuznetsov et al., 2010). Digital progresses and democratization of new technologies led the world to Thingiverse, the largest online design community for digital fabrication. Thingiverse was founded in November 2008 by MakerBot5, a major manufacturer of consumer 3D printers. The site is structured as a design repository and social network for hobbyist digital fabrication where community members can submit designs, give comments and suggestions and share designs with others (Oehlberg, Willett & Mackay, 2015). Communities such Thingverse, but also Youmagine and Raverly, are Makers communities that allows geographically distributed users to share designs with each other. In those sites they have the possibility to download publicly available design files and realize them in the form of real objects by utilizing 3D printers. They also allow participants to engage in remixing activities. As introduced by Chris Anderson *the ability to easy “remix” digital files is the engine that drives community. What it offers is an invitation to participate*. Makers don’t need to invent something from zero or have the most original idea, being part of a community gives you the chance to freely participate in collaborative improvements of existing ideas or designs. This lowers the barrier of entry, because it is easier to modify digital files rather than create them entirely. In this idealized view of collaboration, makers collectively contribute to the development of new designs by iteratively remixing and refining one another's work. One maker community that promotes remixing is the IKEA Hacking. In 2006 Jules Yap decided to collect in one single place all the hacking ideas with Ikea's furniture, thus founding Ikea Hacking. Today the community counts more than 5000 hacks from all over the globe and gave the opportunity to everyone to upload, share, download files for remixing, recoding, modifying, realizing and customize furniture (https://www.ikeahackers.net/).

Among collaborative learning environments there are gaming communities: they provide excellent structures to study the way in which members act within an informal learning environment. They are communities built around videogames, in which participants can collect new knowledge, make their own and collaborating with others who are doing the same (Niemeyer & Gerber, 2015). Among those communities there are specific ones that are dedicated to programming and in the development of Mods. Modding, from "*modifying*", is the act done by players and fans of the game of changing a game, usually through computer programming, with software tools that are not part of the game. This can mean fixing bugs, modifying content to improve it, or adding content. Some game companies support modding by releasing modding tools and hosting modders' forums (Poor, 2014). Videogames companies promoting modding allows gamers to express their creativity and to create new contents that add value to the game. Some gamers find modding a formative challenge, more than gaming itself. Moreover, those communities help firms to understand what gamers like the most and what changes they would appreciate to be introduced in the games. Videogame community are a perfect example of an online sharing platform that contains all the characteristics above mentioned, from the connected learning environment, to the creativity expression, to the opportunity recognition by involved firms.

DIY communities in general are the self-actualization of some principles, like low barrier to entry, learning features, open sharing and creativity that can benefit a variety of other corporate, academic and non-profit collaborative environments. These values drive the exchange of ideas that lead to new discoveries and innovations. DIY have been recognized as a vibrant culture with a long history of learning, creating and sharing. The above-mentioned principles are embedded in everyday practices and supported by the technologies that bring DIY communities into being (Kuznetsov et al., 2010). DIY communities represent an important driver of value co-creation and co-innovation. They look at the network structures as a source of jointly value creation and open innovation through access to new skills, knowledge, markets and technologies by sharing risk and integrating complementary competencies. This collaborative endeavour is able to enhance the adaptability and flexibility of their value creating systems in order to react in response to external drivers such as collaborative (business) opportunities (Romero & Molina, 2011). The advantage for companies who decide to interact with Makers communities are strictly connected with the new Open Innovation Paradigm (Chesbrough, 2003) that fosters firms to look beyond their boundaries when innovating, searching opportunities and new ideas outside their R&D departments. Thanks to the web 2.0 and democratization of new technologies, Maker communities' participants are able to explore every branch of knowledge and share all the information related, exchange knowledge and create new skills and capabilities online. Companies should become aware of the huge potentiality that they can find inside communities, that are a totally new, prominent source of creation of value for customers. Firms should also consider that community members, in most of the cases, don't have the purpose to capture those value created by themselves because they have non- economic interests. In this scenario firms could enter in a soft, easy way and try to find patterns that make the community-firm relationship possible and convenient for both parts.

1.3.2 Social Networks

One of the strategies adopted by companies to involve a large number of customers includes the use of social networks. The prevalence of web 2. 0 techniques have led to the creation of a multiplicity of virtual communities within the limits of social networks, such as Facebook, Instagram, Twitter, Myspace, which, thanks to their structure, facilitate the creation, sharing and dissemination of information among web users.

Some researchers say that the success of the social network is due to the fact that the owners of a profile can let others know who they are and, in so doing, satisfy a fundamental need, that one of being known by others. The principle behind the social network is therefore to make itself known by focusing on its social dimension. Boyd and Ellison (2007) gave a definition of social network sites as web-based services that allow individuals to (1) construct a public or semi-public profile within a bounded system, (2) articulate a list of other users with whom they share a connection, and (3) view and traverse their list of connections and those made by others within the system. The nature and nomenclature of these connections may vary from site to site. What makes social network sites unique is not that they allow individuals to meet strangers, but rather that they enable users to articulate and make visible their social networks. This can result in connections between individuals that would not otherwise be made.

Social networks constitute a network in which people can nurture various social bonds, ranging from casual knowledge, to employment relationships, to family ties. Apparently, it is an instrument with purely personal purposes, but actually it represents a great potential for business and their customer relationship management. Social networks have the power to change the way we think, interact and see the company. They are extremely important tools within the company because they facilitate the exchange of information according to a bottom-up approach, in total contrast to the traditional management programs or applications typically used in the company, such as SAP, that provide a top-down management of information. Social networks are presented as authentic online services and platforms that are essentially based on the identification of the individual/company (often defining the specific profile), highlighting their social relationships and providing a series of additional applications that give the customer great freedom of participation. This tool gives users the opportunity to share ideas, activities, events and interests within their own network of relationships.

The advantages of using these tools are particularly linked to the ease of finding and involving people in order to spread information very quickly and to the possibility of creating relationships across geographical and organizational boundaries, by defining a common context for sharing information and knowledge, all based on structuring and formalization of a large stock of human attention on which the ads market is based: the phenomenon of Influencers is emerging, especially on Instagram, thanks to which targeted advertising and loyalty campaigns are created, where a profile - specifically that of the Influencer - becomes a brand ambassador and promoter of a specific product or a specific company.

Other advantages are related to the reduction of the production costs of content or software applications, generated in a collaborative way by the members themselves, as well as advertising costs, as advertising goes from outbound (interruption marketing) to inbound, focusing only on potential real customers and avoiding the dispersion effect of other media such as newspapers, TV and radio. In addition, social networks leverage on the advantages introduced by the spread of web 2.0 with regard to human aggregation at low cost: memberships are voluntary, content is self-produced, links are not instrumental, the costs of acquisition and management of the relationship are borne collectively by the network itself.

Furthermore, some of this social networks, among others Facebook and Instagram, allows for a cheap advertising campaign evaluation; like for Google Ads, there are tools such as Facebook Ads and Instagram Insights that allows to keep records about the effectiveness of social media posts, like how many people they reach, how many react, their age and geographic location, how many of them clicked on the link connected with the social post and a series of other statistical and informational data that helps company for a low-cost/democratized customer relationship management.

1.3.3 Blogs

The term web-log, or blog, was coined by Jorn Barger in 1997 and refers to a simple webpage consisting of brief paragraphs of opinion, information, personal diary entries, or links, called posts, arranged chronologically with the most recent first, in the style of an online journal (Doctorow et al., 2002). A blog, short for Web log, is a powerful two-way Web-based communication tool. A blog is a Web site where people can enter their thoughts, ideas, suggestions, and comments. Blog entries, also known as blog posts, are made in journal style and are usually displayed in reverse chronological order. A blog entry might contain text, images, or links to other blogs and Web pages, as well as to other media related to its topic. Most blogs are primarily textual, but some are enriched with photographs (photoblog or photolog), videos (videoblog or vlog), or audio (podcast). A blog written from a mobile device such as a pocket PC, mobile phone, or PDA is called an Mblog, and real-time blogging is known as liveblogging. A blog can be private (internal to an organization) or public (open to anyone) (Murugesan, 2007). Blogs have several unique characteristics that together distinguish them from other forms of electronic communications such as email, instant messaging, short message service, and multimedia message service. For example, Blogs exploit the peculiar characteristic of New digital revolution tools, that is the democratization of new technologies: anyone can publish a blog post easily and cheaply through a Web interface, and any reader can place a comment on a blog post. These blog posts and comments are instantly available on the Web. This posting and commenting process contributes to the nature of blogging (as an exchange of views) in what Yale University law professor, Yochai Benkler, calls a weighted conversation between a primary author and a group of secondary comment contributors, who communicate to an unlimited number of readers. It also contributes to blogging's sense of immediacy, since ‘blogs enable individuals to write to their Web pages in journalism time – that is hourly, daily, weekly – whereas the Web page culture that preceded it tended to be slower moving: less an equivalent of reportage than of the essay’.

In addition, blogs are easy to find. Another unique characteristic of blogs is that a blog post can link to other blog posts, so interesting posts travel from site to site. And, through these linked blogs, people with similar interests can build relationships and form communities. Finally, blog allows the creation of a temporary permanent relationship, by the subscription: if you subscribe a blog, you will be notified, usually by an email, when there is a blog update, and keep adjourned with what you are interested in. Many businesses use blogs to connect and engage with customers, employees, and the general public.

1.3.4 Web innovation contexts

Another effective tool that requires the collaboration of customers is the online competition and contests, in which the company requires its consumers or people in general the solution of specific problems or the creation of new products in the form of competition. This new business strategy, facilitated by the creation of web platforms, requires the company to have extensive management skills and the ability to encourage customers to participate. The use of this strategy and this kind of tools has been mentioned several times in the literature, especially in association with the concept of spreading the new paradigm of open innovation. One of the most diffused types of Innovation/Problem solving online context, which is part of the open innovation strategies, is the crowdsourcing.

Crowdsourcing is considered to be one of the most applied models of co-creation. The term was originally coined by Howe in 2006 and defined as a new web-based business model that uses a distributed network of individuals to find creative solutions for existing problems. He defines crowdsourcing as a business practice that means literally to outsource an activity to the crowd. In fact, crowdsourcing is literally asking to the crowd for solutions to a determined problem. Firms utilize this Open Innovation tools to reach solutions outside their R&D departments – potentially all over the world – and to gain advices, new ideas and concepts, new points of view that internally are difficult to be created. One of the most utilized Crowdsourcing platforms is InnoCentive.

InnoCentive’s Open Innovation Marketplace connects organizations seeking solutions to important challenges they face with an unrivalled network of expert problem solvers that can offer diverse perspectives and fresh insight.

If a company has a problem and asks for public help from more than 375,000 people around the world, how likely is it to find at least one that can solve it? A lot of them. This is at least what the InnoCentive community thinks, which defines itself as the world's largest platform for problem solving through innovative ideas. It is an open innovation marketplace on which organizations can launch open competitions to find a remedy for certain problem issues. To provide possible solutions online, according to the dictates of crowdsourcing and a methodology called Challenge Driven Innovation, is a network of almost 400 thousand solvers (scientists, researchers, experts in various disciplines and passionate) from more than 200 countries around the world. Anyone who can give the idea that meets the needs of the company that published the challenge earns a cash prize that can be worth tens or hundreds of thousands of dollars, depending on the complexity. There have been challenges rewarded with even a million dollars. Among the biggest clients of InnoCentive we find Ford, General Fusion, Procter and Gamble, The Economist and others.

It is important to point out that Crowdsourcing is not only for start-ups, but rather it involves and it is used by all of the world’s 25 most valuable brands ranked nowadays by “Interbrand”. Apple, the company which is on the top of the rank, has never used crowdsourcing in its history until April 2015, when “eYeka” (a creative crowdsourcing firm) discovered the WWDC 2015 Scholarships contest, in which the Californian brand asked students for application ideas. Google, the second best global brand, launched the Doodle 4 Google 2014 contest and eleven-year-old Audrey Zhang of New York was the winner, receiving as reward a $30,000 college scholarship for herself and a $50,000 Google for Education technology grant for her school, Island Trees Memorial Middle School, a Google Chromebook computer, an Android tablet, and a T-shirt featuring her Doodle.

There are many other examples of this type, real competitions based on the selection of the most promising and potentially feasible ideas. This kind of competition can take different arguments, structures and organisations:

- *IBM* with the Global Innovation Jam, by means of which it wants to identify new market opportunities going beyond traditional brainstorming aimed at generating new ideas. “In a world where innovation is global, multidisciplinary and open, you need to bring different minds and different perspectives together to discover new solutions to long-standing problems. Therein lies the essence of collaborative innovation. IBM's Jams and others Web 2.0 collaborative mediums are opening up tremendously possibilities for collaborative innovation ways of working across industries, disciplines, and national borders" (from www.collaborationjam.com);
- *Siemens*, which collaborates with the German company Initiative D21, has launched the project Initiative D21 Vision2Market: the goal is to create new products, services and processes. The winning ideas are then realized and subjected to market tests (www.initiatived21.de);
- *Microsoft* with Imagine Cup, which encourages young people to create new technologies or to develop innovative products.

- *Sanofi Genzyme*, in collaboration with Maker Faire Rome and ASTER (Emilia-Romagna company for innovation and technology transfer), launched for the first time in 2016 the MaketoCare context, aimed at bringing out innovative projects that are born to solve the problems of people with disabilities. (www.maketocare.it)

These online competitions often have common features: they are generally managed online, thus exploiting the applications provided by web 2.0 and therefore the advantages of managing virtual communities (ease of access, overcoming geographical and temporal barriers, exchange of information and opinions and joint definition of product design); the relationships in innovation contests are limited in time and can last from a few days to several months. The companies that use this methodology mainly belong to the B2C field. Here too, the dissemination of internet has played a decisive role in ensuring the exchange of information and programmes on a large scale, encouraging the involvement of a greater number of actors, who can more easily intervene, add functionality and make changes.

1.3.5 Online product configurators

Web-based product configurators are enablers of the concept of product customization, as they allow customers to transform their perceptions regarding a desired product into a precise product specification. The customer chooses option values within set limits that best match his configuration goal (Hansen, 2003). A multitude of firms today integrate customers using the potentials of Electronic Commerce into their value chains. Thanks to this particular kind of Web 2.0 instrument customers become “prosumers” who are able to determine attributes of the desired product themselves within predefined limits. The possibility of personalization can be realized within the seller’s process using the concept of Product Customization, that allows customers to create products that offer enough variety and customization so that nearly everyone finds exactly what they want and what respect its needs. The configuration of an individual product is then realized by the customer in a special phase of customization. An additional degree of personalization can be achieved by offering user individual services, a unique product image, a variety of delivery options or even individually developed and produced product components. This process allows an important creation of value, since customers that are completely satisfied for a personalised product are willing to pay more.

Within the customer’s process, the buyer can choose from a range of offered options and option values. By combining desired options starting from a defined product structure, the customer can construct an individual product. The interface between customer process and seller process includes all interactions between the two actors and can be supported using information and communication technology, and in the specific by the use of product configurators. They allow the customer to transform customer's perceptions into a precise product specification using selection and assessment of offered options and option values within a predefined product model. Symptomatically it can be said that the customer has the possibility to configure a huge number of products from a seller's view (Hansen, 2003).

Consumers can design their own personal watches (www.121time.com), their shoes (https://www.nike.com/it/nike-by-you), their shampoos or conditioners (https://prose.com/consultation), their bags (https://www.monpurse.com/eu/), their jackets – even with their portrait (https://themightycompany.com/collections/jackets), their strollers (https://my-joolz.it/), their dog accessories (https://susanlancidesigns.com/collections/design-your-own), their keyboards (http://www.wasdkeyboards.com/index.php/), their Muesli cereals (https://www.mymuesli.com/), their teddy bears (https://www.vermontteddybear.com/), their bicycle (https://www.missionbicycle.com/bike-builder) and an infinite number of other products and services. Even cars are being put together by customers in configurators; in the German market, for example, over 70% of car customers configure their vehicles online. It is estimated that worldwide, more than 40,000 configurators are in place in virtually all industries, allowing customers to design their own products (Herrman, 2011).

1.4 The Centrality of People in the Digital Revolution

> *"Because of the rush of human knowledge, because of the digital revolution, I have a voice, and I do not need to scream."*
>
> Roger Ebert

Schumpeter sustained that economic growth is a result of innovations that are identifiable in new combinations of products, processes, markets, sources of supply, and organizations. The number of potential innovations is virtually unlimited. This means that all the technical possibilities that can be commercially exploited are impossible to be known at any time. New combinations are discovered through experimentation. When technical possibilities are identified and converted into economic opportunities, they become elements of the economy. The economy can be viewed as a system coexisting elements and connections. Greater connectivity among actors and ideas creates more possible combinations through identification of existing opportunities and discovery of new ones. Technological change occurs when the relationships among elements change or when new connections are established. The probability of discovering new combinations increases with the number of connections. The new Digital manufacturing and the consequent new connectivity through the Internet gives rise to a massive increase in the number of new possible technical combinations. The more people are connected and the greater the variety of ideas, the greater is the number of new combinations. But the conversion of new possibilities into profitable business opportunities is by no means automatic. Only when the actors in the innovation systems and competence blocs interact with each other closely and frequently enough do the new technical possibilities result in economic growth. The greater the number and variety of actors with different beliefs and expectations, the greater are the chances that new ideas will result in economic growth (Carlsson, 2004).

The Digital Revolution was capable of one of the best innovations in the global environment: giving a voice to everyone, thus proportionally increasing to the infinite the possibility for interconnection. A revolution always came during the history timeline with the democratization of some specific tools thus allowing improvements in the standard of life of people. With the Second Industrial Revolution, for example, became easy for the large part of the people to buy a car. Today, with the magnitude of this fourth Industrial Revolution, everyone has the power to do everything. The best outcome for companies is to become closer to people. Lots of theorist in the literature have always argued how much importance has the people in general, and in the specific the consumer, for companies. Developing a customer-based business approach for a company is an inimitable source of competitive advantage, if it is done the right way. Eric von Hippel (1988) identified four external sources of useful knowledge: (a) suppliers and customers; (b) university, government and private laboratories; (c) competitors; (d) other nations. The company that is able to exploit new digital tools in order to receive as much information back from the market as possible, is the one capable of important economic improvements. Global competition really does require recognition of the primacy of the person. The person in a common context, in a group, in a collective dimension. The digital revolution is not - only - a technological revolution. The pervasive and engaging nature of the digitisation of most activities (production, consumption, citizenship) creates an environment, a new way of living and working1. It is therefore a new way of producing and using knowledge, to which we must become accustomed and which, above all, we must help to create, following our imagination of the possible and our subjective inclinations. A new cognitive ecosystem is taking shape in which many micro changes that emerge from below give rise, self-organizing, to a network of quite elastic whole: a mobile ground of exchange and sharing in which there coexist spaces of autonomy for each node, and mechanisms of relationship that continuously renew the bonds of whole. Although the initial - and more visible and emblematic - focus of change can be seen in the intelligent factory, in reality digitisation invests in a transversal, and interconnected, way the use of knowledge in all sectors and in all functions of people's living and working. Alongside material fabrication, digitization has fueled a cognitive revolution that gives voice to the company outside the company, creating a network of knowledge and collaborations that has led and will lead to innovations never before had.

Andrew Feenberg, a leading technology philosopher and researcher, argues that expanding technology to include alternative interests and values can be a tool of inclusiveness, an important participatory role for users (Veak, 2006). There is rich empirical evidence that the locus of innovation is increasingly shifting from producer firms toward users of products and technologies, i.e., that innovation is becoming increasingly democratized (Von Hippel, 2005). From an interview by Alberto Cipriani (2018) with Carlo, a worker at a large company in southern Italy: “To be competitive on the market, it is not enough to answer the customer's questions, it is no longer enough to produce quality products, but it is now necessary to make new services related to the product available to the customer and to ensure that any new request from the customer, where by new we mean precisely a customization of the product itself, the production system is able to receive the requests and offer them in the shortest possible time. A quick response that is flexible to the most varied requests, ensures that the production system itself, and therefore our company acquires credibility towards the customer by creating a real loyalty with the customer himself.”

1.4.1 Product Customization

“Mass production works for the masses, but what works for you?”

Industrial production started with the transformation from craft production to mass production with strict division of labour and standardization. In this environment, the organization structure was focused on increasing outputs and productivity disregarding variations in customer needs. The focus was on productivity and increasing in the output offered, without taking into account the customers’ demand. As the market saturation increased, the attention shifted to consumers and manufacturing companies were forced towards product differentiation. The growing demand of customized products in combination with decreasing product lifecycles asks for Industry 4.0 tools implementation and exploitation in order to reach further transformation towards organization structures, which cope with increased product customization.

The democratization of goods, as we stated before, started with the Secondi Industrial Revolution, when Ford based its production on large volumes at lower costs standardized products. *Any customer can have a car (Ford T) painted any colour that he wants so long as it is black* (H. Ford, 1922). The Mass production allowed to decrease costs and therefore prices, so everyone could afford goods that could not before, like cars. This paradigm affected in an unrecoverable way the industries of all sectors, that even today works on the principle of large volumes at lower costs;

During the 1950s until the mid-1960s, the innovation process was initially based on the technological variable. Each new scientific opportunity gave rise to an innovative linear process in which applications and product improvements found a new position in the market. The focus was on research and business development. The process was entirely focused on the costs and performance of the new technology discovered. At the beginning of the 1960s, in the last century, companies began to recognize the importance and the need to establish a relationship with their market aimed at customer satisfaction: the consumer perceives that consumption satisfies his need, desire, objective, and that this is a pleasant fulfilment. The technology began to be considered, therefore, only as a factor subordinate to the needs that the market demanded, production remained standard and the market began to demand variety and variability of demand. The fourth Industrial Revolution had the objective of introducing continuous differentiations in production, up to a customization of the final product, which is, however, made in large volumes, by allowing involves faster production and flexibility, with greater efficiency and reduced complexity in the production process.

While local craftsmen have frequently become obsolete in the age of industrialization due to the centralization of production capacities (e.g., in factories), new Internet technologies also offer individuals various opportunities to produce and distribute customized goods globally. The Internet thus allows for the aggregation of the global demand for niche products, enabling a sustainable increase of profitable platforms for these goods, such as custom-made products of all kinds (Anderson, 2015).

Companies begun to exploit the leverage of innovation in a customer-centric model as a factor of competitiveness, after years in which technological discoveries and labour costs have been the levers of competitiveness also effective. Innovation is becoming more and more democratic, it leaves the traditional model and promotes the birth of new producers of innovation, such as end users. Industry 4.0 will enable novel forms of personalization. Direct customer input to design will enable companies to increasingly produce customized products with shorter cycle-times and lower costs than those associated with standardization and Mass Production. The producer and the customer will share in the new value created.

It is argued that Digital Manufacturing, along with Product Customization, is not in fact a new concept, referring to old manual craft production carried out by artisans, who were located closer to end users than the factories that emerged during the Industrial Revolution. However, there are certain key differences between the work of an artisan and production through Digital Manufacturing. A good artisan can be consistent in what he/she produces at one location, may even be able to replicate the same product, but there is unlikely to be consistency in the production of the same product across geographies. Digital Manufacturing facilitate artisan works in terms of time and efficiency, allows digital files to be stored and easily reproduced, increase communication and information sharing with external parties through the new web tools, give workers more free time to exploit their creativity and elaborate new ideas. Demand for more individuality and customer-specific product variants, coupled with localised manufacturing, requires new paradigms of production that supplant long-established methods. Small, flexible and scalable geographically Digital Manufacturing units allows just in time delivery, nimble adjustments of production capacity and functionality with respect to customer needs, and sustainable production and supply chains. Industry 4.0 tools introduced a deviation from conventional mass production, not only in terms of scale and location, but also the consumer–producer relationship (Kohtala, 2015). The implication here is a shift from long, linear supply chains, economies of scale and centralisation tendencies, towards a move towards a more distributed production model, that completely revolutionize the relationship between economies of scale and economies of scope in the production process.

1.4.2 Co-production and co-creation

To cite Marx (1844), referring to industrial manufacturing and workers:

> “The worker becomes all the poorer the more wealth he produces, the more his production increases in power and size. The worker becomes an ever cheaper commodity the more commodities he creates. The *devaluation* of the world of men is in direct proportion to the *increasing value* of the world of things. Labor produces not only commodities; it produces itself and the worker as a *commodity* – and this at the same rate at which it produces commodities in general. This fact expresses merely that the object which labor produces – labor’s product – confronts it as *something alien,* as a *power independent* of the producer. The product of labor is labor which has been embodied in an object, which has become material: it is the *objectification* of labor. Labor’s realization is its objectification. Under these economic conditions this realization of labor appears as *loss of realization* for the workers; objectification as *loss of the object and bondage to it;* appropriation as *estrangement*, as *alienation*.” (Marx, 1844).

The Forth Industrial Revolution perform a transformation of the industry that completely reverse the concept of alienation and estrangement of the worker in relation to the objects he produces. The worker can be the producer, the owner, the inventor, the maker, the customer. Everything is changing and a conversion of roles is affecting the way companies create, produces and commercialize goods and services.

The Revolution caused the shifting from an industry based on centralized production to decentralized production and both the workers and the users are transformed from partial participants to total participants of the production. Traditionally, suppliers produced goods and services, and customers purchased goods and services. Today, customers can engage in dialog with suppliers during each stage of product design and product delivery: this establish the development of an interactive co-learning process. Together, supplier and customer have the opportunity to create value through customized, co-produced offerings.

The concept of co-creation and co-production is connected with product customization but, even if there are some characteristics in common, we are not talking about the same thing. First of all, in co-creation, the focal point is the innovation and development of a new product, or a better product, while product customization starts from a product already conceived and developed to made it tailor-made depending on the customers wishes. Another important difference regards the magnitude of the participation. In product customization, the customer is interacting with the company for creating a good for its only personal purpose. The customer remains a customer. In the co-creation the customer becomes the product designer, he become a partner that develop something not just for its own purpose, but a product that will be offered into the market to a multitude of other customers. Obviously, the deeper interaction and involvement required for a co-creation cause sometimes intellectual-property issues, that usually cannot arise in the case of a customization. At some point of the collaboration, customers could start asking: ‘What’s in it for me?’, so companies should payoff/reward those customers that succeed to co-create value with the company in order to avoid having dissatisfied customers, or worse, public battles. (Von Krogh, 2006).

Therefore, firms should be able to engage motivated customers by implementing forms of collaborations that offers the right incentives for both the parties, thus improving the process of new product ideation and concept development in interaction with the business allies in order to add a new dynamic to the producer–customer relationship.

It is also true that, often, the motives that push consumers or users in general to collaborate with the company for innovation and co-creation activities are not merely economic purpose, as we will discuss later in this paragraph. The co-creation of value is a valid opportunity for firms as it can help them to highlight the customer’s or consumer’s point of view and to improve the front-end process of identifying customers’ needs and wants. The customer’s value creation process can be defined as a series of activities performed by the customer to achieve a particular goal. One key aspect of the customer’s ability to create value is the amount of information, knowledge, skills and other operant resources that they can access and use. If a supplier wants to improve its competitiveness, it has to develop its capacity to either add to the customer’s total pool of resources in terms of competence and capabilities (relevant to the customer’s mission and values), or to influence the customer’s process in such a way that the customer is able to utilize available resources more efficiently and effectively (Payne, 2008). An important concept is that the value proposition exists in order to facilitate the co-creation of experiences. Creating customer experiences is less about products and more about relationships which the customer has vis-à-vis the total offering. It involves focusing on “value-in-use” instead of mere product features. Customer value creating processes should not be viewed in the traditional ‘engineering’ sense, but as dynamic, interactive, non-linear, and often unconscious processes. The importance of customers’ interaction in creating value is demonstrated also by marketing theories.

Among them, collaborative marketing is the field that emphasize the most the role of the consumer as co-creator of the product, through the interaction with the company in the innovation process. Especially in the field of consumer goods, the crucial problem in these settings lies in finding the logic to identify more aggregated levels of homogeneous demand from individual personal needs detected in the interaction with the customer (Marchi & Bordoni, 2009).

Consumers, in the global economy, no longer limit themselves to be simple active consumers, but can be now considered prosumers, "*a customer who helps a company design and produce its products*" (Cambridge Dictionary), customers more than active in the process involving the stages of creation, production, distribution and consumption of the product.

One of the first known examples of co-production, in the form of crowdsourcing, appear in 1714, when the British Government needed a solution to "The Longitude Problem" that made sailing difficult and dangerous, killing thousands of sailors every year. The British government offered 20,000 pounds for lay people to find a solution, and the problem was ultimately solved by a working-class person with little formal education.

By recognizing the importance of socio-cultural meanings of products and services for customers, firms have shifted increasing attention to the design of new products. As a product reflects values, emotions, and socio-cultural meanings, product innovation is no longer a matter of functional and technological novelty, but also encompasses innovativeness in design.

Ever since the emergence of the Internet and the existence of novel information and communication technologies, companies have seen the power of the Internet as a platform for collaborative innovation and to reach creative people and customers beyond the organizational boundaries. Online idea and design competitions are popular open innovation tools to get access to highly creative and knowledgeable communities from all over the world within a short period of time and at manageable expense. Moreover, online idea and design competitions enable corporations to be perceived as customer-oriented and innovative which further strengthens the brand and increases customer loyalty (Füller, 2011).

An increasingly borderless, interactive and dynamic environment is being created so that the tools and organisational structures must be adapted to sharing and collaboration in order to allow the customer to enter innovative company processes.

This perspective is at the heart of the themes of open and shared innovation, starting the cooperative process. A cooperative process is a formal relationship between two or more entities involving substantial time, commitments, high levels of trust and significant access to each other's resources to achieve a common purpose (Romero, 2011). Cooperation may involve a determinate level of resources' sharing of and some sharing of risk, responsibilities and rewards in order to co-create value. Furthermore, co-creation can be defined as a cooperative process involving interactions between customers and organisations in all creative activities. The potential of value co-creation is achieved through developing and exploiting these interactions with the final objective of co-designing and co-producing the next level of value for a product or a service, exceeding in this way customers' greatest expectations with an entire experience around their favourite products and services. In this matter, value co-creation can be defined as: 'corporations' processes for co-creating goods, services and experiences in close cooperation with experienced and creative consumers, tapping into their intellectual capital, and in exchange rewarding them for what actually gets co-produced, co-manufactured, co-developed, co-designed, co-serviced and/or co-processed (Trendwatching-Global Consumer Trends, Ideas, and Insight, 2006).

Value co-creation has completely overturned the traditional idea of value creation, where customers were seen as destroyers of the value which organisations create for them' while in alternative, the new value creation paradigm views customers 'actively co-creating and re-creating value with organisations. All these changes are starting a new chapter that provide an expanded role for customers, in new co-creation environments, where customers are no longer passive recipients of goods and services, but active partners co-creating value with organisations. As mentioned by Romero (2011) in today's competitive landscape, organisations as producers of goods and services cannot exclusively create added value for customers. Increasingly, value propositions have to be jointly created by both corporations and consumers as co-producers. In other words, added value has to be co-created in successful interactions between customers and corporations – in what we may call the co-create event – through the personalisation of a product or a service based on customer's specific needs, conditions and personal taste. Following this new value co-creation approach, organisations are trying to re-invent their strategies by participating in collaborative networks in order to maintain their competitive advantages through the emergence of new value creation practices.

The new 'co-innovation/open innovation' model is now integrating customers into active roles in all innovation activities, from idea generation to prototyping, seeking in this way a positive impact in the degree of innovativeness in the next generation of products and services to be launched into the market. Romero identifies different types of value co-creation, described as follow:

- *Product finishing*; like in the Ikea model, in which the customer has the role of product assembler and product deliverer. The producer (Ikea), by outsourcing some labour to the final customer, has the advantage of saving costs in manufacturing, storage and distribution. At the same time, this paradigm benefits the customer with more attractive prices.
- *New product design and development*; like in the P&G case, where customers are invited to participate to the new product development, by sharing ideas and desires, and

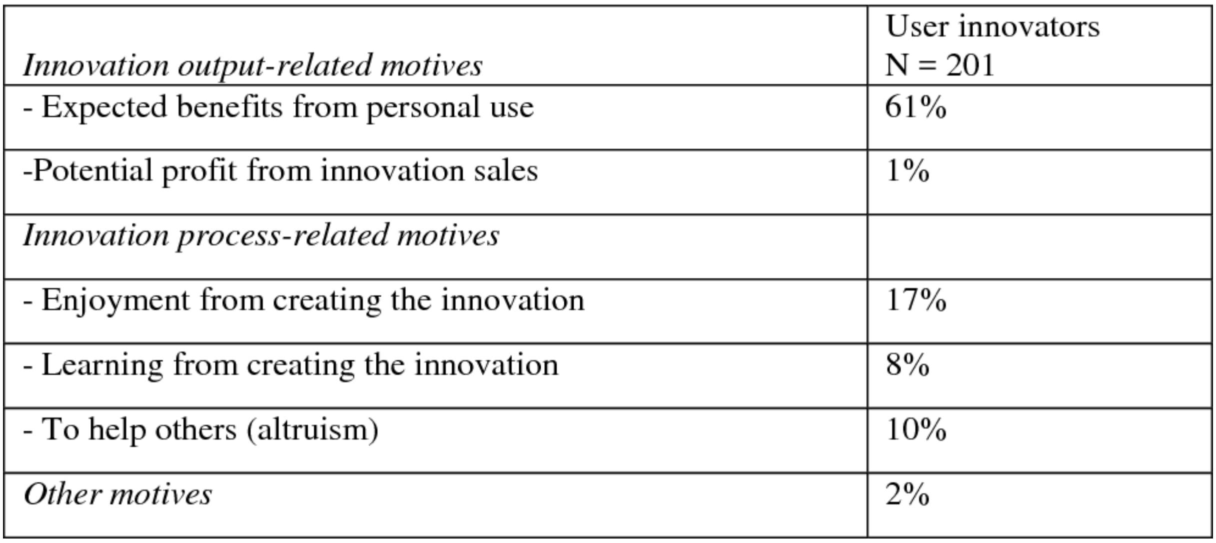
testing new products. The producers benefit from highly innovative markets and increased revenues in niche markets. Customers who independently develop a product are willing to pay more than 100% of its the value. The customer has the possibility to find rapid solutions to its emerging needs. Additionally to lead-users, in recent years, companies have also utilised "early-adopters", as consumers who embrace new products or services before most people do, and "beta-testers", as consumers with a commitment to test and provide ongoing enhancement to a product or a service before its release to the market, ensuring a high quality in final version. Both groups of consumers can enhance the reputation of a product or a service and serve as social leaders promoting innovation by using/testing a product, service or technology that is trying to gain momentum.

- *Existing product adaptation*; like in the case of Microsoft, where the company is always searching for new solutions of existing problems or bugs provided by engineers and experts collaborating in communities. This way, the company receives continuous feedback and can solve programs problems. The customers, at the same time, receive continuous solutions and can benefit from improved software applications. Listening the customers' voice has been always a good way to obtain ideas and insights for successful product adaptation, but a much better way has been putting in the hands of a limited number of consumers' prototypes/products to observe and gain feedback on how the design and features of a product can be improved. Therefore, successful organisations today are those capable to quickly adapt different versions of their products and services according to instant consumer feedback with a real agile product adaptation model competent to support short product release cycles based-on frequent feedback.
- *Mass customization*; like in the Nike case. Nike is offering pre-determined options to the customers by allowing them to customize their shoes. In this case the value created for the company is an economic value, since the company benefit from the increased willingness to pay of customers to have customized products.
- *Open community ideation and product design and development*; like in the Lego case. Lego adopt a strategy for developing and marketing new interactive products in a collaborative process with users. LEGO integrates the customer into the innovation and marketing processes in order to design, develop and sale the best products. Customers can virtually design their own products and order the customised set of blocks to build them and they can program them to be animated.

- *Real-Time Marketing and Service Adaptation*; like in the Fedex case. FEDEX service strategy offers a catalogue of services to be selected by the customer according to its needs and preferences, together with some optional adding value services such as: package insurance, tracking, delivering confirmation. FEDEX adapts its service to win the customers preferences. Conversely, customers will receive more than a typical mailing service including some other added-value services that guarantee the safe package delivery.
- *Personalised Experience Value and Knowledge Co-Creation*; Finally, this is the new value co-creation style like in the Apple case, where the firm and the customer interact within an experience environment to co-create unique experiences of value, or an "experience of one". Apple offers multiple experiences to their customers when they buy an iPOD, through iTunes interactive platform, allowing them to personalise and add content to their devices and evolve them by acquiring and installing new gadgets on them. The producer can improve its brand image and reputation and add a premium for the personalized experience it provides. The customers benefit from all the complementary service that the producer is offering to improve their experiences.

Regardless of the type of collaboration, selecting the right criteria to target the right co-creators is a major task in the process of constructing effective co-creation partnerships with customers and business allies. Therefore, when selecting the most suitable co-creators, companies should bear in mind that not all customers can be good co-creators, but it strictly depends on their knowledge, skills, expertise and behaviours. It is also important to underline that consumers are often driven by not-economic reasons, since they are searching for other kinds of rewards. Consumers experience an increase in the satisfaction of their needs when they are involved in business processes. The best benefits they are recognizing include: greater responsiveness of product characteristics to individual needs, perception of uniqueness in the product produced, the possibility for the customer to also meet hedonistic needs, by virtue of its active role in the co-design process, the possibility for the customer to give the output of the codesign process a higher value, by virtue of personal pride in having contributed personally - proud of authors - and finally the possibility of sharing risks within the community.

Table 2. Kayak case study, motivation for users to participate in the innovation process



Innovation output-related motives	User innovators N = 201
- Expected benefits from personal use	61%
-Potential profit from innovation sales	1%
Innovation process-related motives	
- Enjoyment from creating the innovation	17%
- Learning from creating the innovation	8%
- To help others (altruism)	10%
Other motives	2%

Source: Von Hippel, 2017

Von Hippel (2017), in the case study of the Kayak sector (**Table 2**.), identified the main motivation that push users to participate in the innovation process. The first motive is “expected benefits from personal use”, accounting for 61%, followed by “enjoyment from creating the innovation” with the 17%. The potential profit from innovation sales accounted only for 1% of the motivations registered by participants to the survey. This research shows the huge potentiality offered by involving people in all the different types of collaborations inside a company’s innovative process, that is independent from financial rewards, so it is irrelevant in terms of economic costs, but it gives the opportunity to achieve a wide range of benefits, both for the producer and the final consumer.

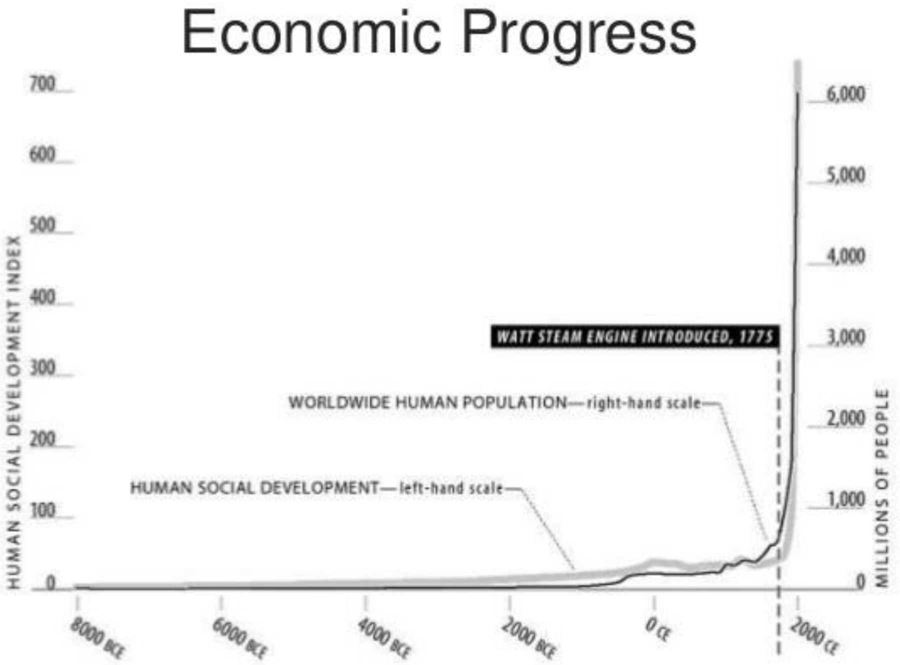
2. The Fourth Industrial Revolution

"The Fourth Industrial Revolution is not just about technology or business;
it's about society."

Joe Kaeser
President and Chief Executive Officer, Siemens

Human history has always been characterized by a succession of transformations and progresses, driven by curiosity and self-actualization needs, yet the speed and effects of the digital revolution underway prove to be unique and disruptive as ever. The fourth Industrial Revolution, exploiting the possibility of millions of people connected by fixed and mobile devices and promoting the adoption of an increasingly broader set of innovative technologies whose development and disclosure speed is increasingly on the rise, is changing the markets and the production models all over the world. Since the time Prometheus stole the fire of knowledge from Mount Olympus and give it to the mankind, humans started to explore and discover, innovate and ideate all throughout their evolution. Over the course of millennia, the human society has always strived to find new and better solutions to satisfy their needs and adapt to the evolutionary changes in the world environment, trying to exploit new opportunities and improve the quality of their life. They had never stopped to pursuing, from a Darwinian perspective, a process of adaptation that allowed them to evolve more and more until they were able to conceive a completely different reality: the one introduced by the Fourth Industrial Revolution. Looking at the historical timeline of Industrial Revolutions in the last centuries it is easy to understand how industry was subject to radical changes due to technical evolution as well as its complete reinvention as well as new resources and means of production were invented or discovered and introduced in production. Those evolutions had such a powerful and disruptive impact that they were labelled with the specific term of "revolutions". If we could travel in the past and go back over two hundred years, we wouldn't be able to recognize the global environment as we know it today, as well as industry, conditions of life, habits. During the last two centuries the world experienced the most radical leaps forward ever recorded in the whole human history, with an increasingly closer temporal progression from a change to another. Most of the things we are used to know in our daily life, were made possible and available thanks to the multitude of inventions that occurred in the last two centuries. Having a look at the **Figure 13**. by Ian Morris (2010), it is possible to evidence the magnitude of the impact that the last revolutions had on the social environment. Over thousands of years – from around the 8000 B.C. until the last years before Christ, human social development was so slow that it is barely remarkable and even non-existent, and this index was strictly reflected into the worldwide demographic population. The curve is characterized by a very slow upward trend, resembling mostly a flat situation. The point of no return is marked by the introduction of the Watt Steam Engine in the 1775, year in which is imputable as well the beginning of the First Industrial Revolution.

Figure 13. History of human social development



Source: Morris, 2010

After the First Industrial Revolution the trend experienced a steep upward tendency; the curve alone is graphically enough intuitive to describe the magnitude of the effects the subsequent revolutions had on the entire humankind. Starting from that point the society begin to behave following some simple economic rules that Schumpeter theorizes as the basic function of the entrepreneurs. The function of the entrepreneur consists of identifying and implementing new possibilities. This economic driving function is achieved by following a series of tasks we can concretely group into the following types:

1) Creation and realisation of new products or new product qualities;
2) Introduction of new production methods
3) Creation of new industry organisations
4) Opening of new outlet markets
(5) Opening up of new sources of supply

The role of the entrepreneur in this sense achieve an increasingly broad and inclusive meaning that, in opposition to the Marxist vision of the alienated citizen, it leaves room for a wider and more free entrepreneurial scene, in which the entrepreneurial spirit belongs to everyone and anyone can become entrepreneur by following its curiosity and passion. Being an entrepreneur is seen by Schumpeter as an act of continuous research and improvement, that is the spark from which the revolutions take place. Marx himself recognizes in his *Capital*, in the chapter dedicated to Machinery and Modern Industry, the revolutionary character of industrial processes, in a time and a context really far from ours, at the dawn of the mechanization of production processes; the analysis is extremely symmetric to the contemporary world and provides a modern view of the revolutionary processes that characterize the current industry.

"*Modern industry never views or treats the existing form of a production process as the definitive one. Its technical basis is therefore revolutionary, whereas all earlier modes of production were essentially conservative. By means of machinery, chemical process and other methods, it is continually transforming [...] the technical basis of production*." (p617)

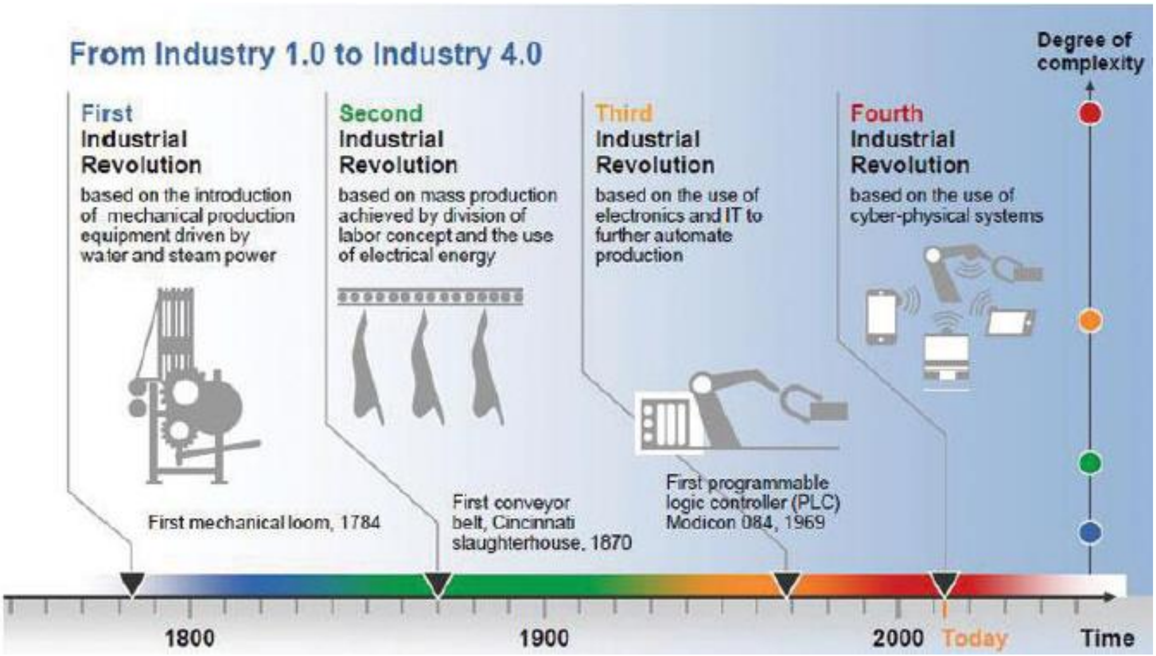
The entrepreneur is a revolutionary, an innovator, a generator of ideas and improvements, directly responsible for dynamic change in the economy. This concept is extremely exasperated and made possible especially with the latest Industrial Revolutions, which gave people a voice like never before in the history of mankind, and the possibility to become entrepreneur in the easiest ways. The most important change allowed by the Fourth Industrial Revolution is the engagement of people. Modern Web instrument allows people to be connected among themselves and connected with firms and industries, creating a network that is able to completely re-shape the economic environment and to push up the Morris' social development curve in a way it was unthinkable before. For the majority of scholars and entrepreneurs, the Fourth Industrial Revolution is recognized as the greatest transformation human civilization has ever known. As far-reaching as the previous Industrial Revolutions were, they never set free such enormous transformative power. The Fourth Industrial Revolution is transforming essentially every human activity: the way we make things; the way we use the resources of our planet; the way we communicate and interact with each other as humans; the way we learn; the way we work; the way we govern; and the way we do business. Its scope, speed and reach are unprecedented. The new revolution is giving us, as citizens, as workers, as entrepreneurs, as people in general an enormous power and infinite opportunities, and this is the reason why it is fundamental to understand in deep the characteristics of the phenomenon to take advantage of it and avoid to fall into the danger such power involves. Industry 4.0 is defined as not just a technology or business revolution, but a *society* revolution because it introduces communication among people outside their boundaries and inside industries, that it is not anymore just sharing of ideas, emotions, contents, images, videos among people already knowing each other, but something that allows unknown people from different places and backgrounds to meet in virtual spaces and create new communities by exploiting the ease of new communication tools. The Smart Factory represents a radical change not only because it introduces internet in its functional organization, but because it allows communication, that is communication between people, and between things and people, in a place that is able to produce by communicating. In this scenario stands the correlation between Fourth Industrial Revolution and customers participation, in a world in which communication is becoming zero-costs and zero-limits, the most powerful resource for a company is to communicate with the most important stakeholder ever: the customer. Global environment really does require recognition of the primacy of the person. The person in a common context, in a group, in a collective dimension. Improve relationships, confront each other to find the best solutions, invest in people, in their proactivity. Enhance more the presence of people – outsiders, workers, customers, makers – in production processes is a powerful resource that can create an invaluable source of competitive advantage for those firm that are able to exploit it the right way. Firms should support people not only individually, but try to build social worlds acting as real communities, sharing communities' rules and principles, allow participants to rediscover the taste of the relationship to get something good and to trace together paths to the future, a mission that remains fascinating as well as challenging.

2.1 History of Revolutions

> *First came steam and waterpower; then electricity and assembly lines; then computerization…*
>
> *So, what comes next?”*
>
> B. Marr, Forbes

Over the course of history, humankind has perfected its industry by not only relying on technical evolution but also by reinventing it as the introduction of new resources have created new technical means. Therefore, during the last centuries, industry has benefited from qualitative advancements which have sometimes been so ingrained in a certain time period and have had such an overwhelming impact that we have classified them as revolutions. The beginning of this ongoing, fast-paced process of technological development can be placed to the late ‘700s, when the First Industrial Revolution introduced water and steam power to mechanize production (**Figure 14**.). The FIR is characterized by the spread of mechanical production equipment driven by water and steam engines, but for mass production the world had to wait until the Second Industrial Revolution, in the late ‘800s, when the first industries started to use electronic power inside factories and implemented the division of labour.

Figure 14. From Industry 1.0 to Industry 4.0



Source: Condor, 2017

The beginning of the Third Industrial Revolution is temporary collocated one century later, exactly in November 1969, when the first programmable logic controller (PLC) was invented by Richard Morley and introduced by General Electrics in the assembly line. The new production system was based on the use of electronic and IT to further automate production.

Today, we find ourselves on the beginning of a new era of innovation with the rise of the Industrial Internet. The Fourth Industrial Revolution has driven the production systems one step ahead from the automated assembly line as it represents the combination of cyber-physical systems and it is taking place by virtue of a more pervasive connectivity, low cost sensorial devices and the power of advanced computing and analytics. The impact these innovations may had on our lives are huge and most importantly disrupt the industry environment. Even if some thinkers argue that this new revolution is merely a prolongation of the previous one, it presents some peculiar characteristics that introduce a radical change in respect of the previous technologies. And, most important, the fourth Industrial Revolution allows social change and affected the social population at each level, in a totally different way in respect to the previous revolutions. In the Green PaperWork 4.0, presented by the German Federal Ministry of Labour and Social Affairs in 2015, is provided a framework about how society will work in the future and what have been the working development and characteristics until today. It outlines main trends, changes in values and important areas for action for the working society. The Paper propose a schematization of the changes in work since the Eighteenth century in relation to the chronological scan of the four Industrial Revolutions:

- WORK 1.0 refers to the birth of the industrial society and the first workers' organisations. The introduction of the steam engine and mechanical production systems led, in the late 18th century, to changes not only in production methods, but also in the organisation of work, social structures and the self-image of the emerging classes.
- WORK 2.0 in the late 19th century, was the beginning of mass production and the birth of the welfare state. Industrialisation led to new social problems and raised fundamental social questions. With the worsening of social problems and the growing pressure from organised labour it began to witness the birth of the first forms of social insurance.
- WORK 3.0 covers the period in which the welfare state and workers' rights were consolidated on the basis of the social market economy. Employers and employees negotiated with each other on an equal footing, as social partners. The need for representation of common interests was unquestioned in companies and among workers. Later, some social rights were revoked, partly as a result of growing competitive pressures. Since the 1980s, production has been further automated through the use of information technology and electronics, the share of the economy accounted for by

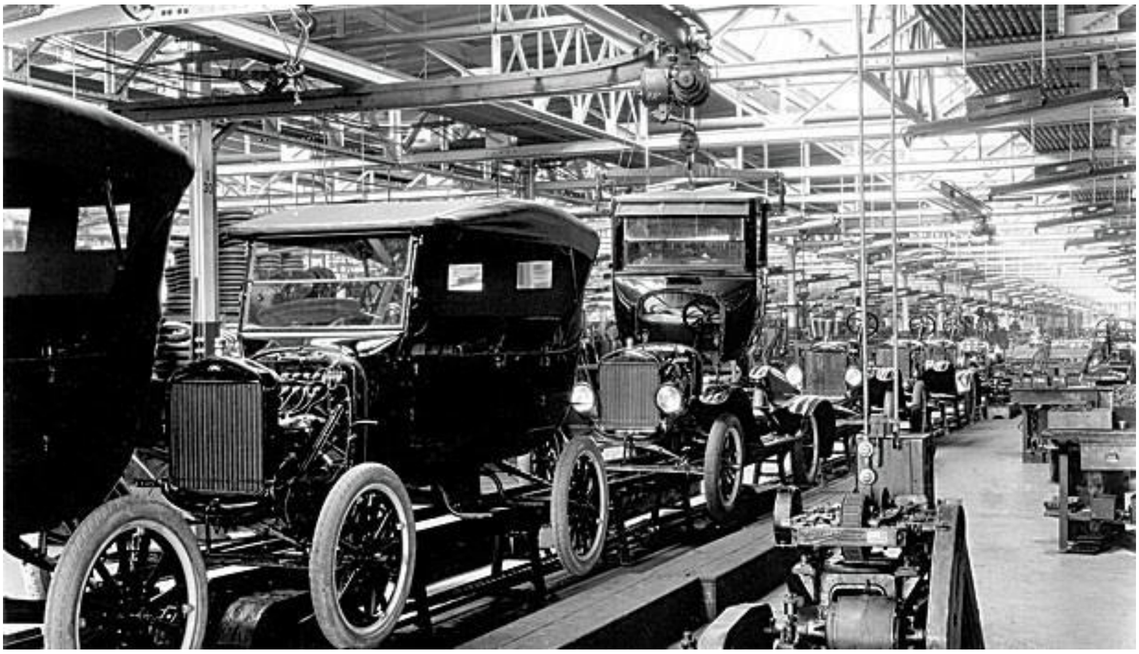
services has been rising sharply, and national markets have been opening up as a result of Europeanisation and globalisation.
- WORK 4.0 will be more interconnected, digital and flexible. The specifics of what the future world of work will look like are still unclear. Since the beginning of the 21st century, industries experienced another fundamental transformation of production method. The growing interconnectedness and rise in cooperation between man and machine is not only changing the way we produce things, but also leading to entirely new ways of doing business as well as new products and services. As a result of cultural and social changes, new preferences are emerging with regard to work, and demand for products and services is also experiencing a change. What effects these developments will have on the organisation of work and social security is uncertain, but they can be shaped by society and policy-makers – just as they could in the previous phases. We are at the beginning of new negotiation processes between individuals, the social partners and the state.

According to the German government, the Work 4.0, connected with the last Industrial Revolution, is something that is still in a development phase, and governments, industries and the society in general are concurring in this process of adjustment to the new environment.

2.1.1 The First and Second Industrial Revolution

Succeeding a slow period of proto industrialization, from the end of the 18th century to the beginning of the 19th century, the first changes in the industrial environment marked the beginning of the first Industrial Revolution. A process of mechanization took place, starting to replace agriculture with industry as the foundations of the economic structure of society. Mass extraction of coal along with the invention of the steam engine created a new type of energy that thrusted forward all processes, thanks to the development of railroads and the acceleration of economic, human and material exchanges. The new factories experienced growing economies of scale thus reducing costs as machines grew in complexity and increasing the production in terms of volumes, time and efficiency. Some major inventions such as forging and new know-how in metal shaping gradually drew up the blueprints for the first factories and cities as we know them today. The technological potential of the First Industrial Revolution is considered less important than the one of the Second Industrial Revolution. The first revolution mainly affected the textile sector but did not affect other manufacturing sectors to the same extent. Only the railways, in the second phase of the first revolution, originated from the use of the steam engine and not from the mechanization, represented a new sector which favoured the mobility of the population and created an extensive new semi-qualified employment in the sector. Nearly a century later, at the end of the 19th century, new technological improvements introduced a new source of energy: electricity, gas and oil. The Second Industrial Revolution is generally considered to have the greatest potential for transforming the economy and society because of the presence of general innovations capable of changing entire sectors and, above all, of generating new ones (Rosenberg & Birdzell, 1988). Electric light was an invention that allowed for longer working days, but also created new space for social entertainment. In factories, the electric motor and internal combustion engine allowed workers to move faster and more flexibly, directly increasing their productivity. Production-oriented scientific research also made it possible to physically manipulate molecules, increasing the supply of synthetic raw materials and lowering their price, as was the case with artificial fertilizers, synthetic dyes, pharmaceuticals and, in the second phase of the Second Industrial Revolution - after the Second World War - plastics. The most significant effect, however, was the emergence of completely new sectors such as the above-mentioned entertainment and information industries, based on electricity, which arrived in a social context where nothing similar existed and which had a huge impact on the daily life of the average family. Electricity allowed the spread of a wide range of domestic appliances in the early twentieth century: radio, telephone, lighting, iron, kettle, oven, stove, fan and vacuum cleaner. In the 1920s, especially in the United States, washing machines, dishwashers, domestic refrigerators and, last but not least, television became widespread. Before then, entertainment and sharing tools were something never taught to be part of the everyday life. This is the beginning of the first step towards social change, which increased rapidly with the successive revolutions, when entertainment, communication and information became the routine in human lives. In the existent industries, the development of the automated production processes started to exploit these new resources to their full potential. Furthermore, the steel industry began to develop and grow alongside the exponential demands for steel. At the beginning of the 20th century the society incurred in a new change regarding the means of transportation with the emergence of the automobile and the plane. All these inventions were made possible by centralizing research and capital structured around an economic and industrial model based on new large factories and the organizational models of production as envisioned by Taylor and Ford: a switch to the mass production allowed by the new means of production and the theorized division of labour. The first to introduce the moving assembly line in 1913 was Henry Ford with the production of his Model T. The assembly line, driven by conveyor belts, reduced production time for a Model T to just 93 minutes. The production was so quick, creating bottleneck for the paint house as the paint do not dry. Decreased costs of production allowed the cost of the Model T to fall within the budget of the American middle class. In 1908, the price of a Model T was around 825 USD, and by 1912 it had decreased to around 575 USD. This price reduction is comparable to a reduction from 15.000 USD to 10.000 USD in dollar terms from the year 2000. In 1914, an assembly line worker could buy a Model T with just four months' pay. Assembly lines also decreased the number of accidents in workplaces. Assigning each worker to a specific location instead of allowing them to roam about dramatically reduced the rate of injury. The gains in productivity allowed companies to increase worker pay from 1.50 USD per day to 5.00 USD per day (O’Hare, 2017).

Figure 15. Ford assembly line, production of Model T



Source: Fine Art America, 1920

The introduction of production lines and mass production inside factories constitute a radical change not only in terms of productivity and organizational methods, but as data shows, they enabled a modification also in the social environment and the standard of life of people. Model T was the first example of democratization of goods in the history: before mass production such kind of products as an automobile were not at everyone’s disposal. Production lines allows that price decrease that changed the rules of the economy and started to give even middle and lower classes purchasing power.

The First and Second revolutions are often considered together in literature under the generic label of Industrial Revolution, to discern it from the following Digital revolution of the late 20th century. The two Industrial Revolutions provided the beginning of the social human development as we know it today and laid down the groundwork for the technical and social improvement came next.

2.1.2 The Third Industrial Revolution

In the second half of the 20th century a new revolution started to appear, when the production automation goes further by adopting computer systems. The third Industrial Revolution, that is also called The Digital Revolution, is characterized by the emergency of a new type of energy whose potential surpassed its predecessors: nuclear energy. This revolution witnessed the rise of electronic, but also the rise of telecommunications and computers. In the industry sector, this revolution gave rise to a new era of high-level automated production thanks to two major inventions: programmable logic controllers (PLCs) and robots. The term “automation” was not commonly in use since Ford decided to establish an in-house automation department in 1947. Automation allowed to bring different devices and interfaces together like mechanics, hydraulics, pneumatics, electricity, electronics and computers (O’Hare, 2017). Modern industrial automation begins with the use of PLCs. The first PLC system has invented for American automobile manufacturers in 1969. PLCs were designed to replace relay logic systems, thus software replacing hardware helped to implement changes in production plans quickly. The first PLC unit, Modicon 084, was designed as an electronic replacement for hard-wired relay systems for General Motors. Before PLC systems, production was controlled by relays, timers and closed-circuit controllers. Before the introduction of PLC systems, in production lines were utilized something like hundreds or even thousands of devices per single assembly line. For this reason, updating and upgrading these systems were quite expensive and inconvenient. The introduction of PLCs means a revolution because it pushed the production process a step further in the continue innovative process in entrepreneurial history; computer-controlled production enabled more sensitive, more efficient and more standardized production. The third Industrial Revolution took place in a lapse of time that was roundly one third of the time needed for the previous two, thus showing the increasing speed of changes typical of the last years, and the rapid technological and social changes that are affecting the world today. This revolution marked the shift from mechanical and analogue electronic technology to the digital electronics we use today. Thanks to the third Industrial Revolution the use of digital computers has become commonplace and the appearance of the Internet connected the world. (Vale, 2016). This revolution was not just a technological revolution affecting only industries, but as a precursor of the Fourth Industrial Revolution, it putted the basis for a radical and faster social change than no other revolution before. In the mid ‘90s the technological improvements lead to a drop of information and telecommunication equipment prices in such a way that even the labour productivity, especially in the US, registered a sharp acceleration. As a result, the new information technologies, as well as internet, computing and new telecommunication methods, allows the exchange of a large amounts of data and information in a rapid and cost-efficient way, a deeper integration of the internal process and more flexibility in operations. New technologies also resulted in more decentralized decision-making organizations and more collaborative working environments. Manufacturing industry was positively affected by computers, that became an integral part in the control of both the planning and production processes, defining what would later be called "Computer Integrated Manufacturing". In the meantime, the creation of the World Wide Web, not only changed the approach to production, but allows to connect billions of devices as to create new platforms for commerce and social interaction. The revolution creates a pattern of disruptive change in the society and in the job market, challenging the rules and the believes by which we live and operate. The Third Industrial Revolution results in a new era characterized by knowledge and information-intensive innovations rather than resource-intensive innovation as the precedent revolutions. It started a process of adjustment that modifies in an irreversible way our socio-industrial development, the way we live, we communicate, we work, we spend free time. According to Schwab (2016), the Third Industrial Revolution is nothing more than the first part of the Fourth Industrial Revolution, which lays the foundations for digital diffusion but differs from the subsequent revolution in speed, scope and impact on economic systems.

2.2 The New Industrial Revolution

> *"We had the PC and we had a life – today our devices and sensors will become an extension of us. Facebook is an extension of us. Our phones are extensions of us. Our smart watches are extensions of who we are and what we do. This fourth revolution has the same triggers as the third revolution, but it's cyber meets human this time. It's the same in businesses. Everything gets integrated, customized and smart-automated."*
>
> Van Duüren, 2017

The First Industrial Revolution was limited to using water and steam to mechanize production and provide a first change in the industry and in the social environment by the creation of new cities in which people and especially workers moved to live; the Second Industrial Revolution used electricity and internal combustion engine to create mass production, increase productivity and introducing totally new sectors especially in the field of cars and entertainment. The Third Industrial Revolution, that of ICT (Information and Communication Technologies), used electronics and information technology to automate production and innovate consumer goods already present in the Second Industrial Revolution (Schwab, 2016). The Third Industrial Revolution could be qualified as an information revolution, for the application of ICT to production: the computer that makes production more flexible on the one hand and globalises the financial markets on the other, is flanked by the container that globalises the goods market, accelerating the speed of transactions and the reduction of transport costs. Today a Fourth Industrial Revolution has come, which builds upon the Third revolution and the Digital revolution that has been taking place since the middle of the last century. This Fourth revolution, with exponential expansion, is characterized by merging technology that blurs the lines between the physical, digital and biological spheres to completely uproot industries all over the world. The extent and depth of these changes are a sign of transformations to entire production, management and governance systems. The speed of the discoveries that date back to the Fourth Industrial Revolution has no historical precedent. Compared to previous Industrial Revolutions, the Fourth evolves at an exponential and non-linear pace and transforms almost every sector in every country. In addition, the breadth and depth of these changes suggest the transformation of entire production, management and governance systems. The Fourth Industrial Revolution is not only about smart and connected machines and systems. Its scope is much wider. Waves of breakthroughs are occurring simultaneously in areas ranging from gene sequencing to nanotechnology, from renewables to quantum computing. It is the fusion of these technologies and their interaction across the physical, digital and biological domains that make the fourth Industrial Revolution fundamentally different from previous revolutions. The Fourth Revolution is classified as the continuum of the Digital revolution because it is characterized by the increasing integration between technologies, between man and machine, between machine and machine in cyber-physical environments (intelligent factory, big data, Internet of Things), and by increasingly sophisticated logistics. It appears as an acceleration, a rapid evolution, of the characters of the Third Revolution, in a tendency of technologies to progress at an ever-faster pace. (Schwab, 2016). According to the World Economic Forum (2016) we are in front of a technological revolution that will fundamentally alter the way we live, work, and relate to one another. In its scale, scope, and complexity, the transformation will be unlike anything humankind has experienced before. We do not yet know just how it will unfold, but one thing is clear: the response to it must be integrated and comprehensive, involving all stakeholders of the global society, from the public and private sectors to academia and civil society. The Fourth Industrial Revolution is evolving at an exponential rather than linear pace, its scope is much wider and its impact far-reaching. Its force is disrupting almost every industry globally, and the depth and breadth of the changes it is carrying along with it are announcing the transformation of entire systems of production, management and governance. The possibilities of billions of people connected by mobile devices, utilizing unprecedented processing power, storage capacity, and access to knowledge, are unlimited. These possibilities call for technological innovations in areas such as artificial intelligence, robotics, Internet of things, autonomous vehicles, 3D printing, nanotechnology, biotechnology, materials science, energy storage and quantum computing, capable of completely changing the profile of global society. Mokyr (2015) defines the Forth Industrial Revolution as something that will bring “disturbances and pains", but, he ensures, the new technologies will certainly be able to make improvements to production systems and create a new demand for workers to carry out tasks that each new technology creates. For example, in 1914, no one could have imagined occupations such as video game programmers or cyber-security workers, personal trainers and physiotherapists, social media consultants and television sports commentators, all professions created by new technologies. Marr (2016) defines the Industry 4.0 as the embodiment of the existence of smart factories where web connectivity enables machines to be virtually augmented and connected to a system that can envision the entire production chain and make decisions on its own. Bernard Marr continues – these technologies do not only have a tremendous effect on businesses efficiency, they will also help restore the natural environment through improved asset management, potentially even undoing all the damage previous Industrial Revolutions have produced. According to Rullani (2018) the digital revolution transforms the way we produce and use knowledge by setting in motion four high-powered drivers.

a. The *new multipliers* of *codified knowledge,* which, once transformed into bits (0. 1), becomes replicable and transferable at no cost (in space and time). Even if codifying a knowledge costs money, the advantage of this step is that after the codification you will be able to multiply the re-uses of the same knowledge, in different places and fields of application, also leveraging on the rapid and low-cost propagation guaranteed by the global network.

b. The *new creativity* of *generative knowledge* that, thanks to the sharing environment made possible by communication and interaction on the web, can be developed at lower costs and achieve a network of possible users in a collaborative key. The experience that people and companies have in the network allows them to move to the frontier of innovation (technological but also of use), to improve the creation of bonds, reputation and sense, adding the three sources of value that arise from collaboration and co-investment in view of common projects for the future.

c. the development of *extensive self-governing systems* that are connecting robots, IoT (Internet of Things) network sensors, learning algorithms, connections via Cloud, data analysis, thus making it possible to automatically manage problems of low and medium complexity, which previously required important human intervention. In this way, in the digital ecosystem, emerge fields of relationships that are governed by themselves, requiring the intelligence of men only to create and renew the program, and to evaluate its outcomes (correcting unwanted consequences and unforeseen variants). The advantage of this greater autonomy of the machines is not only in terms of cost, speed and efficiency of service, but also in terms of the possible increase in complexity at lower costs, which is governed by the automatisms. The production system generates greater utility, and therefore greater value, as it succeeds in increasing the variety of services provided to users. Moreover, the self-governed system is often able to cope with the emergence of unforeseen situations, ensured that they are framed in the field of its learning codes.

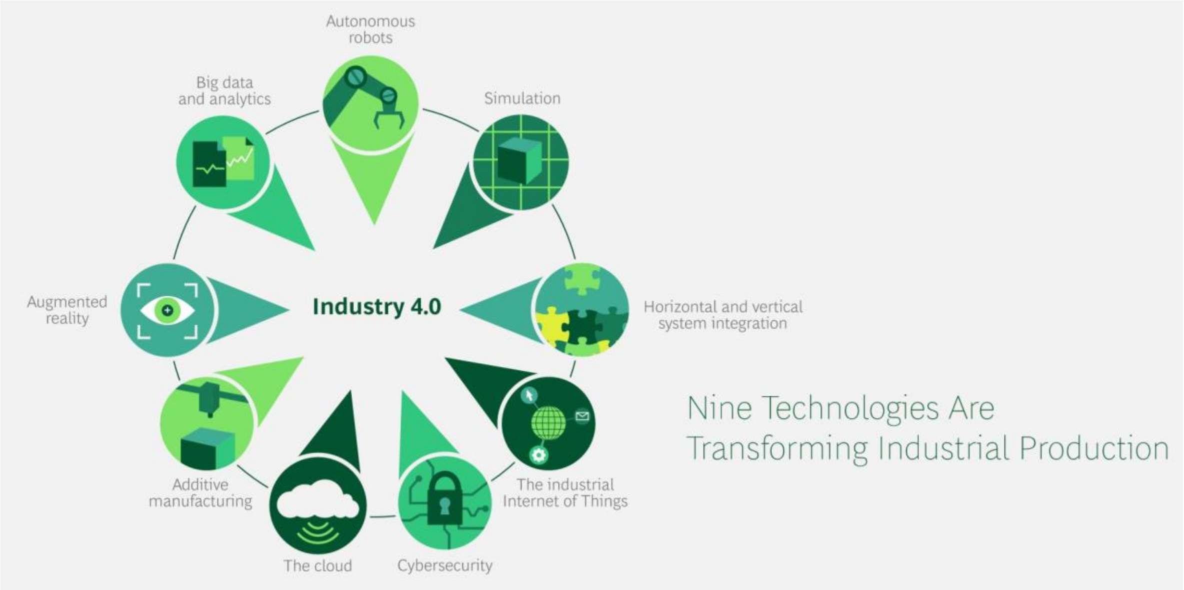
d. The *growth of the complexity* of products, services and solutions developed by the digital ecosystem, for all those innovations that go beyond the intelligent mechanical automatisms. This tendency to increase useful complexity breaks with a past tradition that saw complexity as turbulence or variance out of control, i.e. as an inconvenience to be prevented or corrected, bringing the world back to the standard and the norm. Today, on the other hand, digitization allows for the cost-effective growth of complexity with value for users, freeing up everyone's initiative skills, thanks to the technical and organizational tools that make it manageable. To manage the complexity of production with useful value, the intelligence of men works using the (subordinate) intelligence of machines, through a whole series of devices that ensure a constant connection between man and machine (smartphones, sensors, wearable devices), destined to become a sort of extended prosthesis of the operator's body and mind. Using these tools allows to open new possibilities for the use of human creativity, thanks to the mediation of the digital network and by exploiting the intelligent automatisms, which lower the development and production costs. On the one hand, it allows manufacturers to create new products and services that are personalised, shared or corresponding to market conditions, without increasing costs. On the other hand, it stimulates demand to imagine new possibilities, moving towards the frontier of world making. In the digital network, the fluid interaction that emerges from the bottom up is in fact much better than before to efficiently organize the relationship between those who have skills and those who have needs or desires to be met using the available capacity (sharing economy, servitude). This evolution towards increasing complexity - on both the demand and the supply side - is one of the most relevant ways in which the digital revolution creates additional value over previous ways of living and producing. And it calls into question both the new capabilities of the machines and - for more complex operations - the intelligence of men. As a result of these four drivers (replication multiplication, interactive creativity, self-referenced automatisms, expanded complexity), digital has a disruptive effect on most existing sectors, because it puts pressure on competing (pre-digital) solutions and the corresponding competitive structures. But it also has a propulsive effect because it pushes the most dynamic actors to innovate, setting in motion - in a mix from time to time - the four drivers of the value mentioned above.

Like previous revolutions, the Fourth Industrial Revolution has the impetus to alter the national and global economic and power balances, as well as to improve the quality of life of people and workers throughout the world. Booking a taxi, buying an airline ticket by making online payments, as well as accessing content through mobile applications or buying a product on online shop windows, are just some of the benefits we enjoy daily. Similarly, technological innovation can lead companies to lower production costs, higher earnings and higher productivity. Transport and communication costs are decreasing, logistics departments and production chains use shared communication channels, research, development and marketing departments have the means to put the right attention on the product. That's why the Fourth Industrial Revolution is not just about technology or business; it's about society. It is fascinating when a computer beats the best human GO player, when bots write texts, and machines "talk" to each other. Nevertheless, we humans define the algorithms that govern machines and not the other way around. And make no mistake about it: we are now writing the code that will shape our collective future. Although it is not possible to predict which technologies will have the best in terms of diffusion and consolidation, there is clear evidence that the definition of a digital transformation plan and its correct implementation, regardless of the technologies used, is having a strong impact on businesses, to the point of distorting their strategic positioning. From both a production and a distribution point of view, the efficiency of the company's vital activities - and therefore the ability to carve out slices of the public and market - increasingly depends on the adoption of the right technologies. When we talk about a fourth Industrial Revolution today, it often comes across as if new technical possibilities and trends will inevitably revolutionise our lives and our world of work in line with their requirements. Yet this is not the case at all. Technology merely creates new possibilities. It is still up to us to decide which of these possibilities to accept, and to shape our lives and the world of work.

2.2.1 Industry 4.0 tools

Industrial and manufacturing companies are experiencing today the opportunity to increase their competitiveness and efficiency through the interconnection of plants and people, exploiting the cooperation of internal and external resources by aggregating and analysing even large amounts of data. These possibilities are multiplying day by day thanks to continuous investments in 4.0 instruments. Industry 4.0 different equipment must be integrated in an automation solution in order to optimise and bring improvements to production processes. In recent times, equipment and automation systems evolution has allowed to make communication more efficient among components of a solution. Current automation architectures in operation show the necessity of flexibility and modularity with interoperability between manufacturers to allow for optimized and efficient systems. The exponential arising of 4.0 technologies – like additive manufacturing, autonomous robotics, Internet of Things and other technologies referred to as Industry 4.0 technologies – is impacting today's manufacturing system as an accelerator or catalyst that enables individualized solutions, flexibility, production efficiency, cost and time savings in industrial processes and higher quality-level, all factors that together contributes to the increasing of the creation of value (Saturno M., Pertel M., Deschamps F., 2017). In this paragraph we will focus on providing a global definition for the major instruments introduced in industry 4.0. Knowing and analysing the functions of these tools helps to grasp their merits, defects, limitations and opportunities.

Figure 16. Industry 4.0 Nine Tecnologies



Source: BCG, 2015

The Boston Consulting Group (BCG, 2015) – **Figure16.** - brings a selection of new technologies identified as necessary for the future of productivity. They identified a group of 9 technological advances fundamental to support the industrial production of the future:

I. Big data and analytics
II. Autonomous robots
III. Horizontal and Vertical system integration
IV. The Cloud
V. Internet of Things
VI. Cybersecurity
VII. Additive Manufacturing and 3D printing
VIII. Augmented Reality
IX. Simulation

2.2.1.1 Big data and analytics

One of the new industry 4.0 technology is identified by Big data: today is possible to create, share, communicate, store and analyse huge quantities of data thanks to million sensors placed in industry machineries and in the physical world in general. In our everyday life we are used to perform a series of acts that now have become natural but that would not be possible with an invisible network of data. There is not a single definition of the phenomenon, but we can easily refer to big data as anything that can be collected through computer storage and analysis. According to McKinsey Big Data refers to *datasets whose size is beyond the ability of typical database software tools to capture, store, manage and analyse.* It is important to underline that they intentionally don't give a precise and detailed definition because, according to them, it is important to leave a certain amount of freedom to the evolution of the phenomenon and to distinguish between the different applications of big data in different field of industries can bring to diverse outcomes. *Big data in many sectors today will range from a few dozen terabytes to multiple petabytes (thousands of terabytes).* The term can be used to indicate vast, rapidly growing, diverse and often unstructured sets of digitized data that are difficult to store and analyse using traditional databases. As a result, the data represent one of the main cornerstones of the fourth Industrial Revolution. Nowadays, living in a digitalized world, we produce and utilize large volumes of data through any type of object or device connected to the network.

When we talk about Big Data, we not only refer to the actual amount of data, but we are also referring to its analysis. Every significant amount of data, in order to be usable, must be processed through the creation of data analytics, able to produce adequate and relevant information for making decisions. For industries, the analysis of the data is a delicate matter, because it allows them to have insights about their business and their customers, to evaluate their performance, to make more accurate forecasts in order to take the right decisions.

In the early 2000, one of the first definition of Big Data appears, formulated by the analyst Doug Laney, the so called 3Vs model, that describes Big data through three dimensions:

- *Data volume:* refers to the volume of data an organization needs to store. Since incrementing the data volume decrease the value of each data point, in an increasing data environment, a company should be able to select, store and analyse data that rely on a financial justification.
- *Data velocity:* refers to the speed at which data is generated and processed. Currently firms have started to highlight the need for real-time, streaming, continuous data access, made possible by the unprecedented increasing transmission's speed, creating new challenges to enable real-time data management.
- *Data variety:* refers to the fact that today data applications are creating, consuming, processing, and analysing data in a wide range of formats and types from diverse application domains (numerical, structured, unstructured, email, video, audio etc.).

Two dimensions were further added to the initial Laney's definition:

- *Variability:* it refers to the changes in information flows that are negatively affecting the daily, seasonal or event-related data management.
- *Complexity:* it refers to the multiple origin of data that makes it hard to connect, pair, arrange and transform transversal information despite the relevance of finding correlations and hierarchical relations between collected data.

Despite all the criticism and issues related to the big data management process, especially in the industry sector, McKinsey (2011) estimates that a retailer using big data to the full potential, has the opportunity to increase its operating margin by more than 60%. As a result, companies should be aware of the importance that data have in the modern era, that has become equivalent in importance to the other essential factors of production: assets and human capital. The opportunities offered by big data are constantly evolving, driven by technological innovation as well as analytical capabilities of data handling and consumers' behaviour. Big data represent an extremely powerful tool that is able to connect business to consumers and receive information that are precious to business decisions making success.

2.2.1.2 Autonomous robots

Robots represent another fundamental tool of Industry 4.0. The term "*robot*" is not referable to a specific device, but encompasses various and different kinds of devices. Despite this fact, it is possible to identify a universally accepted definition of robots provided by the ISO (International Standards Organization). A robot is defined as *an actuated mechanism programmable in two or more axes with a degree of autonomy, moving within its environment, to perform intended tasks. A robot includes the control system and interface of the control system. The classification of robot into industrial robot or service robot is done according to its intended application.* ISO 8373 (2012). A robot is defined as a manufacturing device whose programmed motions don't need physical intervention and can be adapted to different purpose and utilizations by adjustment of mechanical system.

There are so many diverse applications for robots, for that reason they come in different sizes and shapes. They can be categorized using several parameters, but the most frequently used is the classification given by the International Federation of Robotics (2018) that distinguish between different types of robots depending on their mechanical configuration:

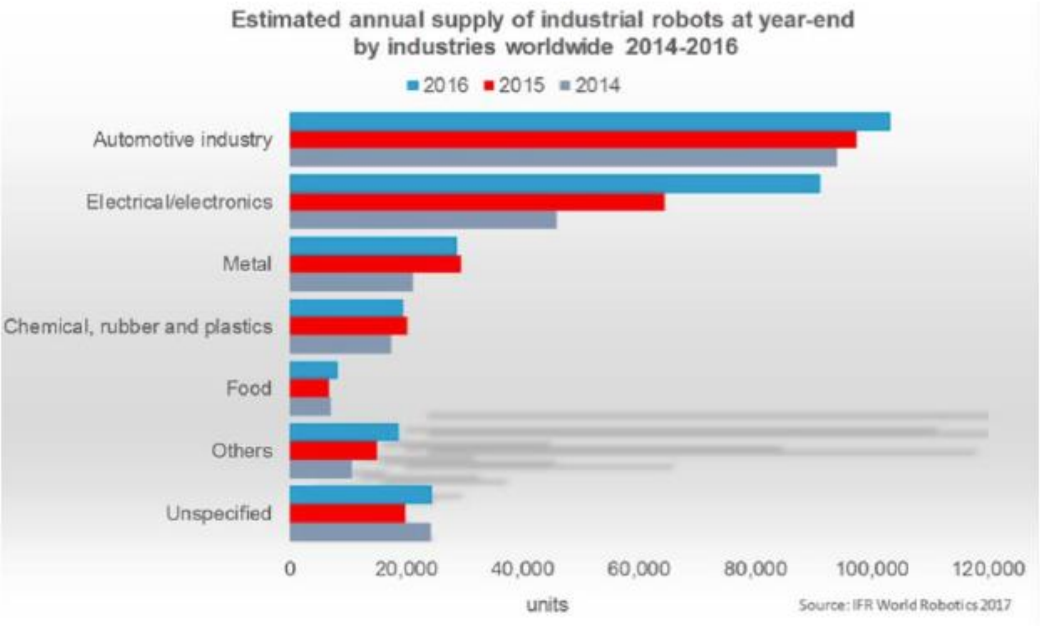
- *Linear robots* (including Cartesian and gantry robots): robots whose arm has three prismatic joints and whose axes are coincident with a Cartesian coordinate system;
- *SCARA* (Selective Compliance Assembly Robot Arm) *robots:* robots, which have two parallel rotary joints to provide compliance in a plane;
- *Articulated robots:* robots whose arm has at least three rotary joints;
- *Parallel robots:* a robot whose arms have concurrent prismatic or rotary joints;
- *Cylindrical robots:* a robot whose axes form a cylindrical coordinate system.

Another category of industrial robot that seems to be increasingly spreading in big companies is represented by Automated Guided Vehicles (AGV), which are typically used for the movement of materials inside a manufacturing facility or warehouse. These are usually connected to a central server, allowing for coordination and automation of their actions. They allow the movements with minimal human input, transporting materials across the factory avoiding obstacles, coordinating with each other to prevent collision, and identifying where pickups and drop-offs are needed in real-time. They are a proof of how robots can improve efficiency and punctuality, diminish perils inside the factory and give employees room to focus on production operations without losing time for internal logistic. A further interesting robot category is the one of *Cobots* (or collaborative robots). A Cobot is a robot whose aim is to physically interact with humans in a common workspace, contrary to the other robots that are built to operate autonomously. Cobots opened up many opportunities in industry sector. Industry 4.0 allows not only to substitute manpower with smart robots, but it depicts an era in which robots and humans are working side by side. This is also possible thanks to the nascent Internet of things and the big data.

Robots can perform multiple tasks inside the factory, like welding, picking and placing, painting, assembling, packaging and labelling, palletizing, product inspecting and moving, testing. The implementation of this tasks by robots in a factory lead to several benefits. Thanks to their precision, they allow to decrease errors and waste production, thus resulting moreover in higher quality of the final products. Robots can be efficient not only in terms of quality but also in terms of speed: they reduce manufacturing time, thus increasing productivity. They don't need breaks, vacations, or sick leave like humans, and for this reason the company can save a lot of money – they can incur in production slowdowns and machine laying-ups but the number of contingencies can be slowed down by guaranteeing regular inspection and maintenance of the robots. In certain cases, robots are also capable of space efficiency: they can be installed on walls, shelves, pedestals, wheels, crawler or rails, or wherever is more convenient.

Robots have lots of benefits if applied in industries, and for this reason they are experiencing an increasing spread. According to a research by IFR World Robotics (2017) – **Figure 17.** – the automotive industry is the major customer of industrial robots with a share of 35% of the total supply in 2016. Between 2010 and 2014, it considerably increased investments in industrial robots worldwide. Between 2011 and 2016, the registered increase was on average 12% per year. The number of robot installations rose by cause of investments in new production capacities in emerging markets as well as in production modernization in major car producing countries.

Figure 17. Annual supply of industrial robots by industry, 2014 - 2016



Source: IFR world robotics, 2017

2.2.1.3 Horizontal and Vertical system integration

Industry 4.0 allowed companies, departments, functions, and capabilities to become much more cohesive, as cross-company, universal data-integration networks evolve and enable truly automated value chains. The interconnected technologies that are capable of analysing and sharing information and data, and therefore of interacting with each other, creates a new world of system functionality for horizontal and vertical integration.

- Horizontal integration is defined as the exchange of data between the enterprise and the geographically remote sites across the value chain.
- Vertical integration refers to all key partners in the value chain, from suppliers to companies and consumers, that now are reachable in an easiest way thus facilitating communication.

2.2.1.4 The Cloud

The Cloud, also referred with the technical term of Cloud computing, is one of the latest technologies of Industry 4.0 that are experiencing constant evolution to adjust perfectly to the new industrial paradigm. Cloud computing refers to the common, flexible and open distribution of computing services like networks, servers, databases, software, data analysis and much more tools provided through the IT infrastructures. It is a system aimed at sharing data, information and applications in order to follow the transformation of business models with the necessary capacity. The Cloud is concurring to the new integration of available resources and technologies driven by the Fourth Revolution, thus increasing the opportunities and benefits for companies. The ISO defines the Cloud as a *paradigm for enabling network access to a scalable and elastic pool of shareable physical or virtual resources with on-demand self-service provisioning and administration." (ISO & Qavami, 2014).* The ISO also determine the existence of six key characteristics of the Cloud, that are a broader network access, on-demand self-service, multi-tenancy, resource pooling, rapid elasticity and scalability and measured service. Moreover, it is possible to distinguish among four Cloud computing models (ISO, 2014):

1. *Public Cloud*: cloud model owned by a third part provider where cloud services are potentially available to every cloud-based customer. It is quite inexpensive and flexible, offering several options for companies and allowing each to use a cloud service customized depending on their needs.
2. *Private Cloud*: cloud model where cloud services are exclusively used by only one cloud service customer. it is better to use a private cloud service for companies that wants to protect the information and data needed for its production processes.
3. *Community Cloud*: cloud model where cloud services are shared among several organizations from a specific community that have common interests.
4. *Hybrid Cloud*: cloud model that consists of at least two different types of cloud deployment models, allowing data and application sharing in between the two types of cloud. the hybrid cloud offers organizations additional flexibility and distributive solutions.

Luca Zanetta (2014) of Uniontrasporti, presented an analysis of the Cloud computing, offering a further classification of the phenomena based on the delivery service model. Cloud computing can be divided into:

- *Infrastructure as a Service* (IaaS) –It represents the basic and most popular format of cloud computing for SMEs. It allows to lease CPUs, virtual spaces, networks and operating systems with a consumption-based payment method. The provider is in charge of the maintenance function, while the customer has access to the necessary virtual tools to build its own IT platforms;

- *Software as a Service* (SaaS) – It allows to rent applications on an infrastructure accessible from various client devices through a common interface such as a web browser or a dedicated client. In this case, the provider is in charge of hosting and managing the application and the infrastructures, and at the same time he's responsible the software's maintenance, update and security management. Users only need to log in from any browser and device to access the application.
- *Platform as a Service* (PaaS) – it allows you to rent operating systems, middleware, languages, database technologies and the runtime environment – the platform – needed to develop an application. It is the most practical solution for developers that wants to easily and quickly build their applications without having to worry about the management and configuration of the server, database and storage network needed for the job.

Luca Zanetta also offers a detailed analysis of the benefits of cloud computing. As already mentioned, the flexibility is one of the most important cloud's strengths, because it allows to adjust contract conditions in base of a company's needs. Cloud ensures also a reduction of the initial fixed cost of software and hardware: the cost shifts from Capex (Capital Expenditure) to Opex (Operating Expense), thus ensuring the company to pay only the amount he spends. Another important benefit of cloud is speed, along with accessibility, the applications become independent from the hardware, and are accessible even with mobile devices. They also ensure better management control, reliability and increased productivity, broader geographic scalability, and a reduction of energetic consumption – thus becoming also a green solution. Although the benefits of cloud computing are considerable, there are some concerns related mainly to the scarcity of resources and staff trained on the subject, and the issue of security. In conclusion, cloud technology offers unprecedent opportunities, in terms of storage and networking capabilities and is being integrated more frequently into industry making it easier for businesses to readily change at the speed of new technologies without losing data. These new applications and platform services are easy adaptable to individual needs and able to perform consistently when confronted with an incredible amount of data. Therefore, it appears that the cloud is and will continue to be a way for small to large industries to reach a competitive advantage through innovation.

2.2.1.5 Internet of Things

Internet of Things refers to the new technologies that enable communication between objects, systems, environments and the people who are equipped with them, creating a virtualized version of business processes and operations to manage and optimize them. According to the definition provided by the ISO, Internet of things *is an infrastructure of interconnected objects, people, systems and information resources together with artificial intelligent services to allow them to process information of the physical and the virtual world and react" (ISO, 2014).*

Internet of things gives the world the extraordinary opportunity to create a global connection not only among people, but among physical and virtual things, creating new identities, physical attributes and virtual personalities. The things around us become a system of objects inserted into electronics, sensors, software and connections to the global network of computers. Some example of IoT interconnected devices can be found in the low-power devices – such as smart watches and microprocessors, computers, intelligent and predictive sensors like WSN – Wireless-Sensor Networks, that are intelligent sensors able to monitor and control systems, connected devices, Radio-Frequency Identification (RFID), which are microchips that transmit wirelessly information about the product to which they are associated to a receiving device – that are changing the logistic and supply chains rules, or some of the most common devices such as barcodes, mobile devices, actuators and GPS systems, sensors which allow lights to be switched on and off, to driverless cars, health monitors and the commonly cited "smart fridge", which might one day allow for delivery by drone of grocery supplies without the consumer even having to write a shopping list.

The applications of Internet of Things inside industry lead to enormous changes. One of the main objectives of the IoT is properly to help the manufacturing industry to address major contemporary challenges such as increasing market volatility and complexity, reduce the time and the costs of production, optimizes processes and improve the customer-centric service offer. IoT gives manufacturing companies, and not only them, the possibility of generating new added value. The IoT is changing the competitive landscape of industrial production. Its application inside the digital factory allows to implement flexibility, product customization, real-time dialogue between market, design, suppliers and production, with significant consequences on the decision making. This means that the IoT system will lead to a large-scale deployment of intelligent products and objects, with unlimited applications.

As the technology will improve, the IoT devices will allow even more data collection and storage, expanding the already existent data sharing ecosystem which allows the interconnection between factories and supply chains, going beyond the wall of the single factory to reach the entire network, creating a sort of expanded enterprise.

Among IoT benefits for industry we can find cost and time savings, scalability, improved operational efficiency, improved productivity, the delineation of new business opportunities, reduced downtime, product customization and maximization of asset utilization. The new amount of data connection allows also to implement real-time decisions. In order to take advantage of the benefits of IoT and to increase the value created for customers, business partners belonging to the same sectors should provide higher levels of collaboration, combining products and services to accommodate customers' needs. Moreover, the Industrial Internet will make jobs safer, more productive, flexible and engaging, involving workers and presenting new opportunities for skills upgrade and the creation of completely new positions that did not exist before.

2.2.1.6 Cybersecurity

With the increased connectivity and use of standard communications protocols that come with Industry 4.0, the need to protect critical industrial systems and manufacturing lines from external threats increases dramatically. As a result, secure, reliable communications as well as sophisticated identity and access management of machines and users are essential.

Cyber security is a branch of information security that deals exclusively with information technology. It represents a set of technologies that have the main objective to protect data from unauthorized access, ensuring the necessary security.

As already mentioned, industries are increasingly adopting technology equipment for the purpose of exploiting the big data by collecting in real time detailed data on their operation, then communicate them to other computer systems, subsequently analyse and store them. Companies are daily dealing with a huge quantity of data for the management and control of industrial processes, which most of them are sensible data. Sometimes companies have to share those data also with actors that are external to the firm, for business purposes, like suppliers or end users. This increased network for data sharing can make the global system more insecure and therefore increase the risk that someone will illegally take possession of them. On the one hand the 4.0 industry increased significantly the industries' connectivity networks create an uncountable series of opportunities; on the other hand, the growth in connectivity increased the need for firms to protect industrial systems and production lines from cyber-attacks.

2.2.1.7 Additive manufacturing and 3d printing

We already introduced Additive Manufacturing, also known as 3D printing, together with 3D scanning in the previous chapter, highlighting the enormous potentiality it brings to Makers' communities and people in general, by democratizing the means of production. Here we give some technical definitions derived from the contemporary literature and analyse some applications and possible developments for the future. Additive manufacturing consists of various processes for the creation of solid three-dimensional products, of any shape and customizable, starting from a digital model (Babu, 2015). The creation of objects consists of a progressive addition of material starting from 0 reaching the final objects – different from the CNC machine that utilize a subtractive principle. The definition given by ISO of additive manufacturing (AM) is describing *a process of joining materials to make parts from 3D model data, usually layer upon layer, as opposed to subtractive manufacturing and formative manufacturing methodologies (ISO, 2015),* while 3D printing is defined as the *fabrication of objects through the deposition of a material using a print head, nozzle, or another printer technology (ISO, 2015).*

As explained in the definition, any 3D project realization must start with the digital three-dimensional prototype that will be converted in a standard file to allow the 3D machine to read it and print it. 3-D printing employs an additive manufacturing process whereby products are built on a layer-by-layer basis, through a series of cross-sectional slices. *All you have to do is load a file and you can replicate shapes that are not possible to manufacture through traditional methods. I call it a flexible factory in a box* (Berman, 2012). Today are also available 3D scanners that do the opposite job: they start from a real three-dimensional object and convert it in a digital file. The most important innovation introduced by 3D printers is that it is a manufacturing method of mass production that can offer new opportunities for mass customization. Industry 4.0 and Additive manufacturing allow the co-design of the product, that can be implemented with the collaboration of other companies, customers, suppliers or universities that can take part in the idealization of a different phase of the production cycle that is realized in a subsequent way with 3D printing. One of the most important innovation introduced by additive manufacturing is the ability to obtain, in a single printing session, objects that are traditionally realized through the assembly of multiple separate parts even if these are movable components. According to Barry Berman, additive manufacturing has undergone a three-step evolution process after its conception. In the first phase, architects, artists, and product designers used 3D printing technology to make prototypes or mock-ups of new designs. Today, most 3D printing still revolves around the manufacturing of prototypes and mock-ups.

This was because 3D printers have several key advantages in developing prototypes and mock-ups, like the ease of duplicating products, the lower cost, and the product security and privacy guaranteed. Then 3D printers experienced a second evolutionary phase that involved their use in creating finished goods. This stage is sometimes referred to as *direct digital manufacturing* or *rapid tooling*. It is estimated that in 2012 over the 20% of the output of 3D printers was in final products as opposed to prototypes: this ratio will reach the 50% by 2020. The third phase is the one introduced before of makers and maker communities, where 3D printers start to be owned and used by final consumers, just like traditional desktop laser printers: everyone can potentially be a manufacturer as last year ago, with the diffusion of laser printers, we all become editors. Additive manufacturing offers several advantages not only to industries but also to privates. The first is the flexibility to design and fabricate any shape with (almost) any material. It also ensures a reduced time-to-market and lower prototyping and production costs (no waste material, no traditional sampling, less energy consumed). Another point in favour of 3D printers stems from the fact that they can run unattended, they just need someone to upload the file and refill the raw material and then they will work without assistance needed. They also increase the level of complexity of the production, allowing to increase product quality and to implement mass customization since it lowers the unitary cost of customized products.

All the reasons mentioned above explain why the 3D printing has showed a huge potential since many years, but in order to exploit its full potential in industrial manufacturing some major elements should be revised: fully automation, quality and breadth of materials that can be used. Researchers and innovators already started to work for improvements in these fields, but we don’t know how much time it will take for 3D printing to get closer to mass production.

Now, 3D printing is mostly limited to products that are made by orders, custom shaped, in very small quantities. They allow companies to carry on small quantity of low-demand customized production without incurring in increasing in costs. But as we said before, there is a huge room for improvement and further developments. Most literature experts seem to agree that the 3D printers of the future will overcome all the major obstacles – like accuracy and strength of products, material cost and availability – and higher levels of precision will be achieved. The employment of additive manufacturing will expand beyond its present scope, leading to a decline in raw materials’ prices. As more companies adopt the technology, the price of machineries itself will drop, and when it’ll be low enough for a private investment, the number of printers used for home applications will also considerably grow (Berman, 2012).

The process has the potential to greatly reduces the production cost, requiring as little as 10% of the raw material consumed in traditional manufacturing and employs less energy than conventional factory production systems, that way making entry costs sufficiently lower to encourage hundreds of thousands of small manufacturers: ideally any 3D printer may become a little factory. The science is already moving toward materials improvement: new lighter, stronger and more durable materials are replacing the old ones, like carbon fibre is replacing steel and aluminium. As a result, additive manufacturing is already used in aerospace companies that are applying new designs in order to reduce aircraft weight, lowering the expenses for raw materials such as titanium but also introducing high-tech parts printed in customized shapes. As we have mentioned earlier in this essay, one of the key challenges of companies today is to reach an adequate level to product customization and increase the value offered to the market. 3D printing is the perfect tool for companies searching for this kind of improvement, since it allows products to be manufactured from concept. As the additive manufacturing will improve, many mass producers will be able to offer for the first time more individualization without losing their cost efficiency like economies of scale or scope. This would be only possible if additive manufacturing will be combined with other 4.0 technologies like ERP applications, cloud computing, augmented reality, big data analytics and mobile devices, to cite someone. In conclusion, it is clear that we can positively hope for a good future for 3D printing as a technology and for its business implications and is quite sure that those improvements will positively affect not only firms but also final customers, hobbyists, makers and potential artisans and entrepreneurs.

2.2.1.8 Augmented reality

Augmented reality (AR) refers to computer displays that add virtual information to a user's sensory perceptions. Most AR research focuses on see-through devices, usually worn on the head, that overlay graphics and text on the user's view of his or her surroundings (Feiner, 2002). AR is the addition of virtual objects on the real-world physical environment, that is enriched by images, sounds, graphics, information or instructions that the user can utilize for his own purpose. The goal of an AR system is to enhance people’s perception and interaction with the real world through supplementing it with 3D virtual objects that seem to coexist in the same space. We can distinguish Augmented Reality from Virtual reality that, in contrast, immerses users in a fully artificial digital environment that completely replaces the real world. The main difference stems in the environment: with AR is the real world, while with the VR we are experiencing a totally virtual world. Another difference directly connected is in the experience of the users. An example of AR is the app Pokémon Go, that allows to the players to see and capture trough their smartphone camera small virtual creatures in the real world they are living.

An example of Virtual Reality is the flight simulation that some therapist utilizes with patients that are afraid to flight, and they are fully immerged in a digital flight and feeling as if it was really happening. In fact, these new technologies – AR and VR – allows companies and organizations to reach new levels of information, in real time and at a higher rate of interaction using mobile devices of any kind and any cost, including wearable technologies. These technologies contribute to the reduction of human errors, costs and inefficiencies. They can be applied in various part of the value chain, like product design and prototyping, where allows a reduction of designing time and costs, and permits a visualization of detailed measures and proportion as if it would have been a real model. AR and VR could also help the implementation of production planning and spatial organization – they are already utilized especially in the real estate sector, for restructuring and renovation. The adoption of this technology makes it possible to facilitate any decision related to the production process, like the selection of products and parts, or the simulation of the production chain in order to catch any defect and optimize the process. Thanks to the AR and VR there is also an optimization of the operation procedures, while employees can look at the data in front of their eyes and speed up the entire procedure. In the logistic, AR tools help to locate product in the warehouse but also to verify real time compliance of orders. Finally, those technologies allow some companies to deep the relationship with customers and offer them new services, like virtual apps in which they can see in front of their eyes how the final product will be (Ikea place). Augmented reality may introduce a next step not only in smart working but also in smart mobility: inside cars AR can be utilized for improve safety by collocating head-up displays with all the info available for the driver, avoiding distractions due to look at the dash or at the phone. During the CES (Consumer Electronic Show) in January 2019, Nissan presented its Invisible-to-Visible technology, a system that combines data from the car’s sensors with mapping and other information stored in the cloud: exploiting the three-dimensional augmented reality, this new technology will provide co-drivers who'll answer questions and provide information about the road ahead (Ellis, 2019). There are several cars on the road today manufactured by BMW, Chevrolet, Jaguar, Lexus, Mazda, Mercedes-Bez, MINI, Toyota and Volvo that have augmented reality features. Using heads up displays (HUD) these vehicles project data such as speed, gas levels, lane guidance, directions, and more. Some companies are using augmented reality and their mobile apps to create AR owner's manuals. Drivers can download apps to their mobile device and then use computer vision to identify specific features of the cabin. Then, the relevant information about the cabin's features is presented to the driver. Currently, there is also a lot of aftermarket HUDs available for drivers to modernize their vehicles, so it’s not necessary to purchase a new model to enjoy AR functionality. (Marr, 2019).

2.2.1.9 Simulation

The adoption of some of the most important Industry 4.0 technologies, like IoT, cloud and big data analytics, contribute to the creation of a virtual representation on the different production lines in order to optimize industrial processes. In fact, especially in plants operations, real-time data allows the so-called simulations, that are virtual representation of material reality, which will help operators to test and optimize the setting of production process machinery in the virtual world before setting it in the physical world for the next production line.

Simulations reduces learning-by-doing costs and machine set-up time to make a product's production process more efficient: this leads to an increase in products' quality and reduced waste. The final objective of simulation is to use digital models that can emulate the behaviour with respect to certain objectively measurable dimensions. The new generation simulation systems can benefit from the application of advanced analytics, artificial intelligence and big data, thus allowing an innovative approach to the development, implementation and maintenance of a product.

2.2.2 Manufactury 4.0

The manufacturing industry is going through a period of profound change due to the massive introduction of new information and communication technologies (ICT) directly into the production environment of the factory. This change was triggered by the introduction, within the manufacturing system, of the Industry 4. 0 paradigm. The Digital Manufacturing, already present since the 90s and conceptually linked to the movements of Maker Faire and Fabrication Laboratories (FabLab), is now one of the realities with the highest potential, with dynamics of exponential growth, thanks to the organizational impact that the new business models related to Industry 4.0 introduce in companies and the opportunity to develop application solutions.

In Digital Manufacturing, in fact, innovative logics are configured in order to re-consider the positioning of the company in terms of *go to market*, organization, production planning, distribution process and supply chain. (Venturi, 2015). The introduction of Industry 4.0 paradigm, as already highlighted in the previous paragraphs, provides a high connectivity between the physical and virtual elements that make up the production system with an exchange of large amounts of data and information (Big Data), increasingly available thanks to IoT (Internet of Things). The data are managed both automatically, through sophisticated mathematical models, and through the intervention of the human being in order to make the system faster and more flexible, to ensure a prompt response to the demands of the final customer who is increasingly aware since the customization needs are increasing like never recorded before. In the last fifty years, we have moved from mass production to one characterized by the greatest possible customization of the product. In the manufacturing sector, computer and digital systems have become the main players: interactive and easily programmable robots, 3D printers, simulation between interconnected machines, augmented reality, management of large amounts of data on open systems (Cloud Computing), analysis of a large amount of data acquired in real time (Big Data) have revolutionized the industrial and economic landscape worldwide. That is what is happening in manufacturing right now. What we call Industry 4.0 enables manufacturers to create a "digital twin" of the entire manufacturing environment – from lab to factory floor, from showroom to service. Manufacturers can design, simulate, and test sophisticated products in the virtual domain before making the first physical prototype, before setting up production lines, and before starting actual production. Software helps optimize every process and every task, whether performed by humans or machines. Once everything is checked in the virtual world, the visible results are transferred to the physical world – the machines – and they close the loop by reporting back to the virtual world. This integration of the virtual and the physical worlds has huge impact and it is affecting manufactory industry in a decisive way, and because manufacturing accounts for 70% of global trade, understanding the magnitude of this transformation is really is about "the wealth of nations", to quote Adam Smith (Kaeser, 2018).

The main characteristics of Smart Manufactory, according to the indications of the Ministry of Economic Development are precisely:

- Flexibility, thanks to the simulation in the virtual domain before physical realization;
- Speed, thanks to the use of advanced technologies;
- Increased productivity, thanks to more precise production times and a reduction in the number of errors;
- higher quality and less waste, thanks to real-time production monitoring systems;
- production of innovative systems, thanks to the presence of interconnected systems.

It has allowed the creation of an ecosystem in which machines, digital systems and individuals work together to achieve joint results. Moreover, the production process is no longer linear but becomes iterative, i.e. in a continuous loop of control and command, thus allowing effective monitoring and ready changes to mistakes in the production, loop in which the individual is required to enter added value at each stage. The production environment, which has been created over time as a result of this Industrial Revolution, has lost its peculiar linearity in favour of a cooperative complexity: machines and individuals work in synergy to obtain results and produce objects and services. In this context, which is in continuous evolution, the operator finds himself interacting and operating more and more with interconnected digital technologies and with significant amounts of data that he must use to make efficient decisions. The new 4.0 manufacturing systems that are spreading in large industrial plants are equipped with sophisticated technological interfaces that allow the systematic pooling of the specialist skills of technicians and engineers with the experience of workers, creating through these contaminations a shared business knowledge (Ponzellini, 2018). An optimal man-machine-system interaction becomes more central than ever for the good functioning of the process that insists in this scenario, since it contributes to the optimization of the physical and mental workload to which the operator is assigned.

Thanks to the new technological introductions, the next wave of manufacturing will affect producers’ entire value chain, from design to after-sales service. Along the value chain, production processes will be optimized through integrated IT systems by the introduction of fully automated, integrated production lines. Products, production processes, and production automation will be designed and commissioned virtually in one integrated process and through the collaboration of producers and suppliers. Physical prototypes will be reduced to an absolute minimum since the major prototyping will be done virtually. Manufacturing processes will increase in flexibility and allow for the economic production of small lot sizes thanks to the introduction of robots, smart machines, and smart products that communicate with one another and make certain autonomous decisions. Manufacturing processes will be enhanced through learning and self-optimizing pieces of equipment that will, for example, adjust their own parameters as they sense certain properties of the unfinished product. Automated logistics, using autonomous vehicles and robots, will adjust automatically to production needs (Rüßmann et al., 2015). According to Forbes, in 2014 67% of manufacturers implemented 3D printing either in full production or pilot and 25% intend to adopt 3D printing in the future. Deloitte, in a research of 2015, founded that small and medium enterprises are more willing to introduce digital transformation in respect to big enterprises. But it is also true that some innovation requires such investments that small manufacturers are not able to sustain.

Industry 4.0 has allowed a new centrality of manufacturing, both for small, medium and large enterprises, which after a long phase of decline seems to be able to return to guide the processes of growth in a logic of increasing integration with services. The reshoring phenomena that are affecting important industrial realities in the United States and partly also in Europe testify to the need for advanced countries to rebuild a productive fabric that integrates the development of services with a solid manufacturing base. Global competition, at least for some productions, will no longer be played out, or less and less, on the cost factor - especially for labour - which for a long time has been the basis for company relocation choices, but will be played out on quality, on innovation, on collaboration between the different companies in a supply chain as well as on the specializations of the territories. If the development towards Industry 4. 0 depends on the increasingly massive use of digital technologies and enabling technologies mentioned above, one can imagine an improvement in terms of efficiency and the emergence of new market strategies that bring the product closer to the consumer, based on more symmetrical information, in which the consumer becomes the main actor not only in the sale phase but also in the previous stages of conception and, why not, also of production. (Bianchi, 2018). The digitization of the industry can represent an opportunity for many countries to overcome the crisis. Future technology companies will be able to achieve a trade-off between quality-price-personalisation-sustainability (EU, 2013). But in general, business models will have to be designed enterprise by enterprise, knowing that digital technologies are and must be neutral enablers to be used to make more efficient all business functions, from production to logistics. To do so, however, not only companies but also government must be prepared and ready to face the continuous market changes. In fact, to date, there are several countries that are, or are being, active on the theme Industry 4.0, presenting action plans that aim to invest in innovation. Among these is Italy, the last country to present an action plan, the National Industry 4.0 Plan in 2016, which we will mention later, preceded by Japan (Vale Chain Initiative, June 2015) and France (Industrie du Futur, May 2015), unlike Germany, which was the first to present an action strategy with the “High-Tech Strategy” in 2006, followed later by the United States with the “Advanced Manufacturing Partnership” in 2011.

2.2.2.1 Italian Digital Manufacturing

The phenomenon of Digital craftsmen, already introduced at the beginning of this discussion with the name of Makers, is a reality that is changing the world of work, far from the official paths. If properly supported, this phenomenon can offer new job opportunities and enhance the culture of making, going to impact in a very positive way the Made in Italy manufacturing. Research carried out by Fondazione Nord Est and Prometeia has shown that in companies where digital manufacturing has penetrated, the path of growth in the period 2000-2014 has been much more positive. The production index of these companies, compared to those that have not used 4.0 technologies such as 3D or robotics, is about 70 points higher and the gap between 2009 and 2014 has widened. Moreover, profitability is also constantly higher over the same period, both for investments and sales. We must bear in mind that Italy is a great industrial and technological country, the second largest manufacturer in Europe, the seventh in the world. In 2018, the Italian manufacturing sector had a turnover of more than 900 billion euros, more than 425 thousand companies and 4. 5 million employees. Not only that, one of the leading sectors of Italian manufacturing, that of manufacturers of high technology automatic machines, fluctuates steadily between the third and fourth place in the world among both manufacturers and exporters. (Martin, 2018).

Throughout Italy there are 171 companies that mention digital craftsmen on their websites; these are mainly companies with registered offices in Lombardy in first place (33), followed by Veneto (28) and, a little further away, Emilia-Romagna (21); Lazio in fourth place. Many of these companies are active in the field of information and communication (44) or in the field of professional, scientific and technical activities (43) (in this case designers), but there is also a group of manufacturing companies (18), such as furniture and bicycle manufacturers. In any case, it seems that the concept of *Digital Craftsmanship* has taken root precisely in the three sectors most sensitive to the Made in Italy: design, digital and the most artisanal manufacturing, oriented to quality and custom-made (Barbera, 2016).

The research of Prometeia, which analyses Italian manufacturing companies with a turnover of less than one million euros, which make up 83% of the companies involved in consumer manufacturing and 73% of the companies involved in the technological manufacturing sector, shows that 25.8% of these companies use 3D printing or 3D scanning. The share reaches 33. 3% among large companies (with revenues over 50 million). The use of robotics is more widespread among the enterprises of metallurgy and other metal products (46.6%) and machinery and other means of transport (46.3%). The areas of greatest benefit (real or expected) concern design, in particular the reduction of design and prototyping times (40.2% very much and quite agreeably), the acquisition of the 3D model of existing objects (29.7%), the possibility of producing objects with shapes and geometries that were not possible before (28.9%) and the creation of customer-specific 3D models. The possibility of shifting production to points of sale (4.7%) appears to be of little importance. Among the companies that use 3D printing and 3D scanning, the first benefit identified is the reduction in design and prototyping times (77.5% of a lot and quite agreeable), while the second benefit is the greater involvement of the customer in the design (55.6%) followed by the creation of customer-specific 3D models (56.3%). Factors preventing or slowing down the spread of 3D printing include the limitation of workable materials (43.3% very much or quite agreeably), the investment required for equipment (42%) and software (38.1%).

The growth in the value of additional production generated by a technological upgrade can be quantified, all other factors being equal, in 8.6 billion € on an annual basis (26 billion over a three-year period) which, added to the 2.8% expected average annual growth over the three-year period 2015-'17 for these sectors (Prometeia estimates for May 2015), would increase the turnover of the sector by 4.3%. The estimated additional growth, in addition to generating positive repercussions on the production activity of the related industries, also has expansive effects on employment with additional increases that can be estimated at around 39 thousand units on an annual basis.

Research shows that there is therefore a clear positive correlation between company performance and the use of new technologies, capable of creating growth, added value and employment. It also shows evidences of some of the limits of the Industry 4.0 and in the specific in the additive manufacturing already presented in this research: quality and breadth of raw material, together with the magnitude of the investment.

Digital artisans are the real protagonists of the fourth Industrial Revolution, they put the sharing of knowledge and technology at the base of a production system and, more generally, of an innovative, dynamic economic system capable of creating value even in a period of crisis, as shown by research data. (Reboani, 2015).

Moreover, craftsmanship is one of the distinctive traits of Italian culture and economy: the winning factors of Made in Italy have always been manual skill, ingenuity, creativity, innovation, design, diversification and the propensity to create tailor-made products for customers, even in hi-tech sectors, such as mechanics or means of transport. Artisan that are able to renew their skills in the manufactory industry can increase the overall competitiveness of our industrial system by leveraging on what customers are searching for: history and culture in the products they buy (Miceli, 2011). The new craftsman combines its passion for making with their determination to invent, helped by the democratization of tools determined by the Industry 4.0. As Chris Anderson points out in his book *Makers: The New Industrial Revolution* (2006)*:* the passion for building is the engine of social transformation and sustainable innovation.

Italy can face the new challenges by taking advantage of its strengths, but also of its weaknesses. Italy boasts an important manufacturing base that, despite the deep crisis of recent years, continues to demonstrate vitality and ability to compete on international markets thanks to the vitality of the craftsmen. Italian companies are able to combine tradition and innovation, renewing and enhancing the value of Made in Italy.

What appears to be for Italy the right approach to embrace the paradigm of Industry 4.0, is for to adapt to its own industrial configuration the technological and organizational innovations conceived abroad. By doing so the manufacturing industry would be able to combine together the competences of traditional craftsmanship with the efficiency of new technologies. In order to achieve these objectives in a stable manner, there is a clear need to address some of the structural issues in our production system. New global markets are asking for a new artisan to be more competitive in global markets. There is a need to invest in research, to innovate, to consider crafts not as a legacy of the past, but as a resource, with an history, which has the potential to be the accelerator of innovation.

Italy must solve the difficulty of connecting the system of scientific competence with the opportunities for employment. Industry 4.0 is the challenge that will relaunch the Italian production system, pushing it towards higher levels of productivity and efficiency for the benefit of growth and prosperity throughout the country. For this reason, it is necessary to put in place a strategy that looks at companies and, in the long term, enhances their characteristics - creativity, innovation, quality of production, high flexibility of production capacity - and supports the transformation towards more advanced models, through all the instruments of industrial policy, from taxation to finance and regulation. (Bianchi, 2015).

The rules of division of labour inherited from the past have changed and the impact of new technologies on the Italian manufacturing system will depend on how a world of small and medium enterprises focused on specific sectors (mechanics, design, agri-food, footwear, distribution) will be able to adopt the potential of these new tools. The ability to pass on their innovations and the speed with which they are disseminated will be the keys to the country's future development and growth.

3. Automotive 4.0

"There's no manufacturing business like the car business. If that can be transformed, anything can."

Chris Anderson

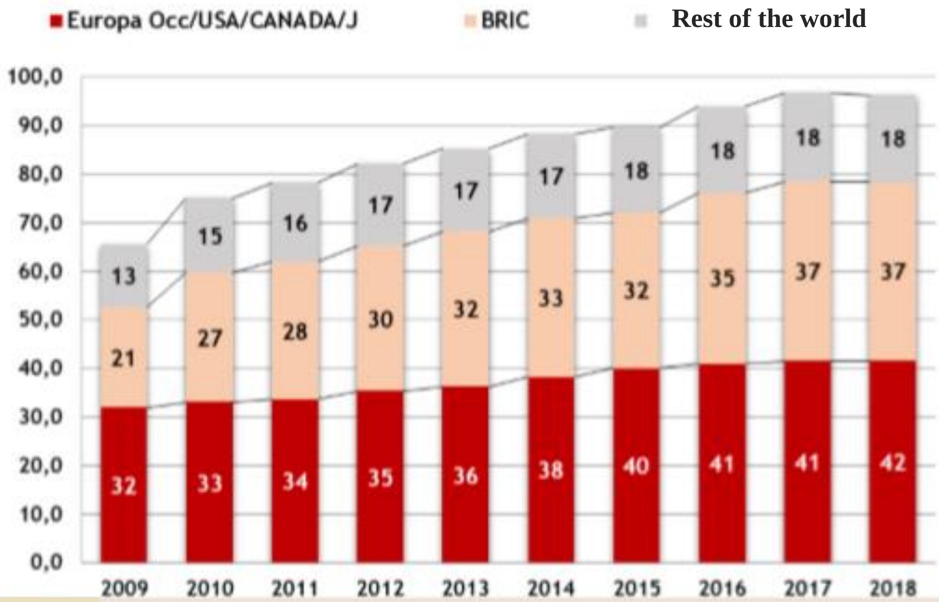
For years, the world automotive industry has been investing in innovation and research into increasingly advanced technologies. The sector has undergone significant changes at a competitive level that have resulted in important innovations, including technological ones. In this context, technological innovation becomes one of the main tools available to the company to be able to successfully respond to the search for variety of consumers, counteracting the growing global competition, differentiating its offer. Those technological innovations comprise digital tools (e. g. 3D printing, the Internet of Things, advanced robotics), new materials, new processes (e. g. data production, artificial intelligence, synthetic biology). A change in the way of production that will have far-reaching consequences for productivity, employment, skills, income distribution, trade, welfare and the environment. Compared to the great challenges expected, the accelerated change of technological focus requires investment in new technologies, such as ADAS and electrification, and imposes a burden on industry without the promise of rapid returns. Many existing skills will be overtaken by new technologies and software, making the audience of stakeholders ever wider and more competitive. Hence the need to transform current business models and to look for new ones and new skills as a differentiating factor for traditional players. Create new partnerships and exploit this ecosystem to find new ways to innovate and create a corporate culture to foster innovation, which is of fundamental importance to compete in new technological areas. The fourth Industrial Revolution represents a crucial challenge for the automotive industry which, through specific investments, will be able to support employment, overcoming the dichotomy between automation and employment, creating new and evolved professional figures at all levels. The new technologies will allow all partners in the supply chain to increase competitiveness by improving and accelerating the development of new products through the use of virtual reality in the design phase, reducing time to market through digital platforms that allow the customer to customize the car, to develop inventory management systems that reduce the rate of occupancy of the warehouse and the investment in stocks in just-in-time view of production, to reduce accidents in the workplace by means of information systems connected to the flow of operational activity and based on a visual and contextual approach suitable for the user, to create a new generation of safer handling and automation systems capable of working more closely with human beings. The contamination of automation, robotics, information technology and application intelligence has led Automotive to be truly one of the most advanced sectors compared to the ideals of Smart Manufacturing. As Aurelio Nervo, President of ANFIA (Associazione Nazionale Filiera Industria Automobilistica - National Association of the Automotive Industry Supply Chain), pointed out at the annual meeting held at the end of 2016 at the FCA plant: “Our companies are called upon to make an important contribution to innovation in the manufacturing sector by exploiting digitisation and connectivity as essential enabling levers for the modernisation of the production system. The Industry 4.0 paradigm can be fully realized in our supply chain, provided that some basic conditions are met: overcoming the size gap and the digital divide of Italian companies, supported by actions to support investment; networking, through the creation of virtual supply chains, the many automotive excellences in the area, focusing on projects that also facilitate the export and creation of value throughout the chain. Finally, an adequate requalification of human capital, through the diffusion of digital skills in their functional, specialized, collaborative and holistic aspects, a greater cooperation with the academic world and a fruitful confrontation with the Social Partners, are another essential point. The paradigm shift in Automotive 4.0, in fact, also includes a new way of dialoguing for all the players involved, including politicians”.

In the automobile industry, small-batch capabilities will allow for more versatility in welding, seam sealing, and assembly using cooperative, autonomous robots. For example, fixed clamping devices currently used in the welding process will develop into adaptive industrial robots that can hold and spin each piece according to the individual requirements of the welding robots. As a result, companies will be able to produce multiple car models with different body styles and designs using one flexible production line. Product and plant engineering can be expanded to multiple product life cycles and models. In the future, the car-making process will be overseen by automatic job-control systems. These will use data integration to modify the manufacturing process automatically, making multiple order systems obsolete. Car component suppliers will automatically adjust their processes on the basis of new orders from the automaker, maximizing just-in-time logistics. According to the Bolton Consulting Group, this change will reduce the costs of logistics and operations. Even if robots will be more autonomous in the car factory of the future, employees will continue to play an important role. Human workers, for example, will be equipped with augmented-reality glasses that can put logistics and manufacturing information in their field of vision. The glasses will use virtual reality to highlight the location where each part should be mounted in the assembly process. Similarly, data glasses will guide consignment employees in selecting the proper parts. Gesturerecognizing cameras will assist workers in performing quality control checks by automatically documenting and storing quality issues, reducing manual paperwork. These advances will enable auto workers to handle a wider variety of car models while reducing failure rates and enhancing quality control and production efficiency. During the lifetime of the car, its virtual model, created in the engineering phase and integrating all relevant data, will constantly be updated with performance data and data from exchanged parts. Using this virtual model, sometimes called the "digital twin," producers can improve their after-sales service, offer a range of new services, and generate insights that can be used to optimize the design of future cars (Lorenz, 2015).

3.1 Automotive industry: an overview

The Automotive Industry is one of the most powerful and big industry in the world, and following its trends is fundamental to have a better understanding of the global economy. In 2018 the global Automotive Industry registered a negative demand. According to ANFIA, the global demand for motor vehicles has affected a total of nearly 96 million units (**Figure 18**.), with a decrease of around 1% on the previous year – in 2017 the demand counted 97 million motor vehicles, and 40 million more than the 57 million annually assembled at the beginning of the century, with a growth of 2% compared to 2016, when the demand reached 94 million units. The demand is driven by Europe, USA and Canada, followed by BRIC countries and the rest of the world. The trend in world sales in 2018 was marked by the first 20-year decline in the vehicle market in China (-3.1%) and decreases in Turkey (-35%) and Argentina (-23%). In the last decade, sales of motor vehicles rose from 65.6 million in 2009 to around 96 million in 2018, with a 46% growth, equal to over 30 million new vehicles. The contribution to the increase in demand is attributable for 53% to the BRIC countries, 32% to the traditional markets of Western Europe, the USA / CANADA and Japan and 15% to the rest of the world. The so-called BRIC countries (Brazil, Russia, India and China) represented, in 2009, 31.5% of the global demand for cars with 20.6 million vehicles sold and in 2018 38% with 36.8 million, thanks above all to the growth of the largest market in the world, China, which has reached, in the last year, 28 million new registrations, equal to 29% of the world total; the increase in volumes was in 10 years of 14.4 million vehicles.

Figure 18. Global demand for cars by macroeconomic area – million units



Global sales – million units	66	75	78	82	85	88	90	94	97	96

Source: ANFIA, 2018

The traditional markets of Western Europe, USA / CANADA and Japan, while increasing the volumes of almost 10 million cars in ten years, have reduced their weight by 6 points, going from 49% in 2009 to 43% in 2018. The rest of the world is worth almost 18 million sales, 4.5 million more than in 2009, with a share close to 19%.

Table 3. shows a more detailed picture of the global situation for vehicles demand. The demand for vehicles in the EU-EFTA, after years of negative signs, has been growing since 2014 and in 2018 has 18.2 million units and it is worth 23% of world sales. The European countries that registered a positive trend in demand are Spain (+6.9%), France (+ 3.3%) and Germany (+0.3%). The US market has registered 17.7 million registrations (+ 0.9%), while in Canada the demand is down by 1.7% with over 2 million new registrations. Here the car market is decreasing to the advantage of light trucks. The car segment is worth 29% of the LV market and that of the light truck 71%. The Asia-Pacific area is worth half the global demand for cars. The Chinese market is the largest in the world accounting for 29.2% of the overall global demand, with 28 million vehicles, of which 23.7 million are cars, which recorded a decline for the first time in 2018 in twenty years of continuous growth (4.3% compared to 2017). Car sales in India exceed for the second year in a row, the threshold of 4 million cars, precisely 4.4 million and an annual increase of over 9%. In Japan, the car market is just above 2017 levels: 5.27 million, + 0.7% on 2017 and a 5.5% share of global demand.

Table 3. Global cars sales: volumes; percentage changes; shares.

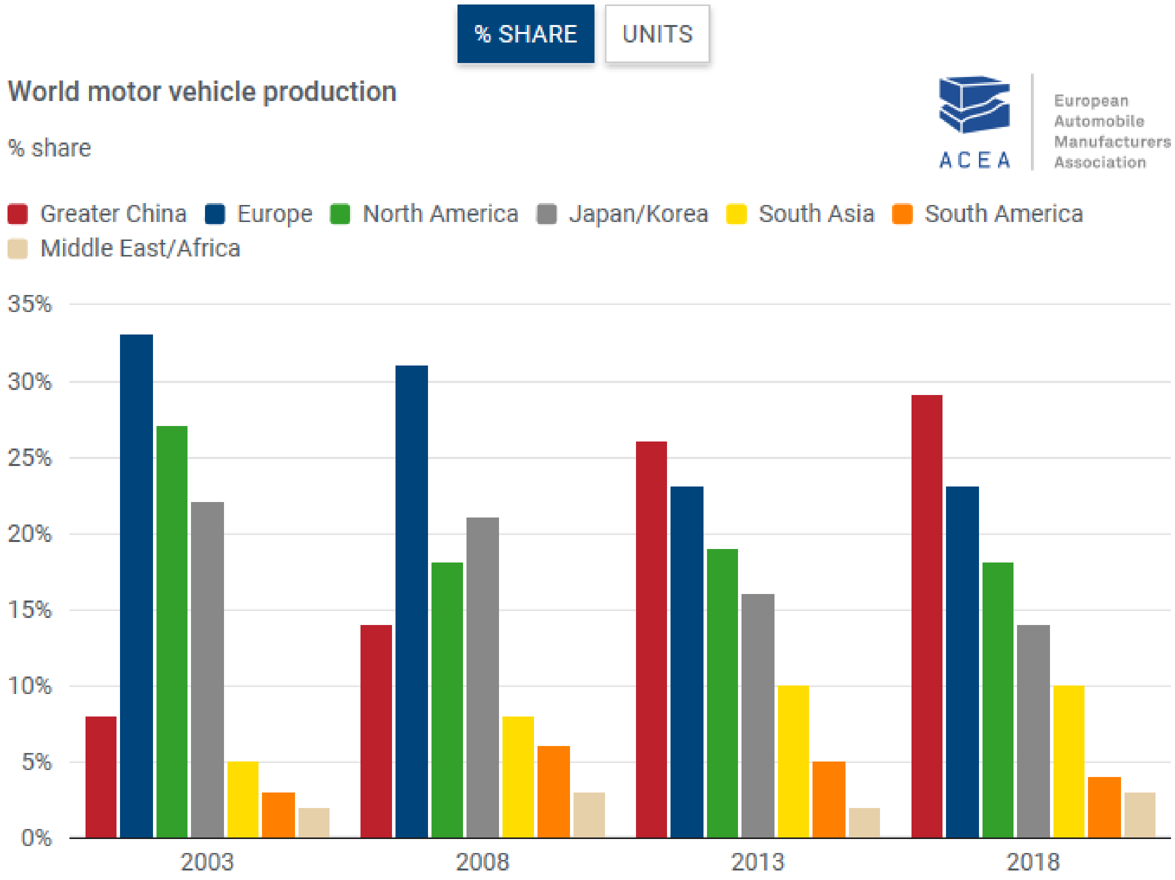
.000 unità	2017	2018	var% 18/17	quote 2018
MONDO	96.664	95.898	-0,8	100,0%
EUROPA	21.095	20.838	-1,2	21,7%
UE-EFTA	18.129	18.195	0,4	19,0%
UE15-EFTA	*16.576*	*16.514*	*-0,4*	*17,2%*
Germania	3.810	3.822	*0,3*	4,0%
Francia	2.606	2.693	*3,3*	2,8%
Regno Unito	2.966	2.784	*-6,1*	2,9%
Italia	2.192	2.123	*-3,2*	2,2%
Spagna	1.462	1.563	*6,9*	1,6%
UE13	*1.554*	*1.681*	*8,2*	*1,8%*
RUSSIA	1.792	1.821	*1,6*	1,9%
TURCHIA	987	642	*-35,0*	0,7%
ALTRI EUROPA	186	181	*-2,9*	0,2%
NAFTA	21.198	21.204	0,0	22,1%
Canada	2.076	2.040	*-1,7*	2,1%
Messico	1.570	1.461	*-7,0*	1,5%
Stati Uniti	17.551	17.703	*0,9*	18,5%
SUD AMERICA	4.570	4.718	3,2	4,9%
Argentina	912	704	*-22,8*	0,7%
Brasile	2.239	2.566	*14,6*	2,7%
ASIA-OCEANIA	48.605	47.866	-1,5	49,9%
Cina	28.941	28.039	*-3,1*	29,2%
Giappone	5.234	5.272	*0,7*	5,5%
India	4.021	4.400	*9,4*	4,6%
ASEAN	3.080	3.179	*3,2*	3,3%
AFRICA	1.196	1.270	6,2	1,3%
BRIC	36.993	36.827	-0,4	38,4%

Source: ANFIA, 2018

The ASEAN countries total the record level of 3.2 million of new vehicle sales (+ 3.9% compared to 2017). In the last ten years, sales in the ASEAN area have increased by 71%; Indonesia, Malaysia and Thailand are the most important markets. Sales of motor vehicles in Africa, although on the rise, represent just 1.3% of world sales in 2018. Moving the analysis on the production side, shows us which are the principal players of the Car Manufacturing sector. According to a research of the ACEA – European Automobile Manufacturers Association, the leading producers of cars and automobiles in the world is China (**Figure 19**.). It accounts for nearly 30% of the total world motor vehicles production, with a production of nearly 28 million, experiencing a decrease of 4 percentage points in respect to 2017. At the second place we find the European Union, registering a production of 23% on the total production, accounting for more than 22 million units produced and a decrease of 0.2% related to 2017 values. The third place is the one of USA, accounting for 18% and a unitary amount of 17.5 million cars produced, nearly stable in respect of 2017 production levels. The fourth leading country is

Japan, that together with Korea accounts for 14% of the global production, and 13 million unit produced. They registered a decrease of production of 0.8 percentage point in respect of 2017. The following producer countries are South Asia, South America and Middle East/Africa, that register respectively the 10% (+7,2% on 2017), 4% (+3.9% on 2017) and 3% (-2.2% on 2017) of the global motor vehicle production.

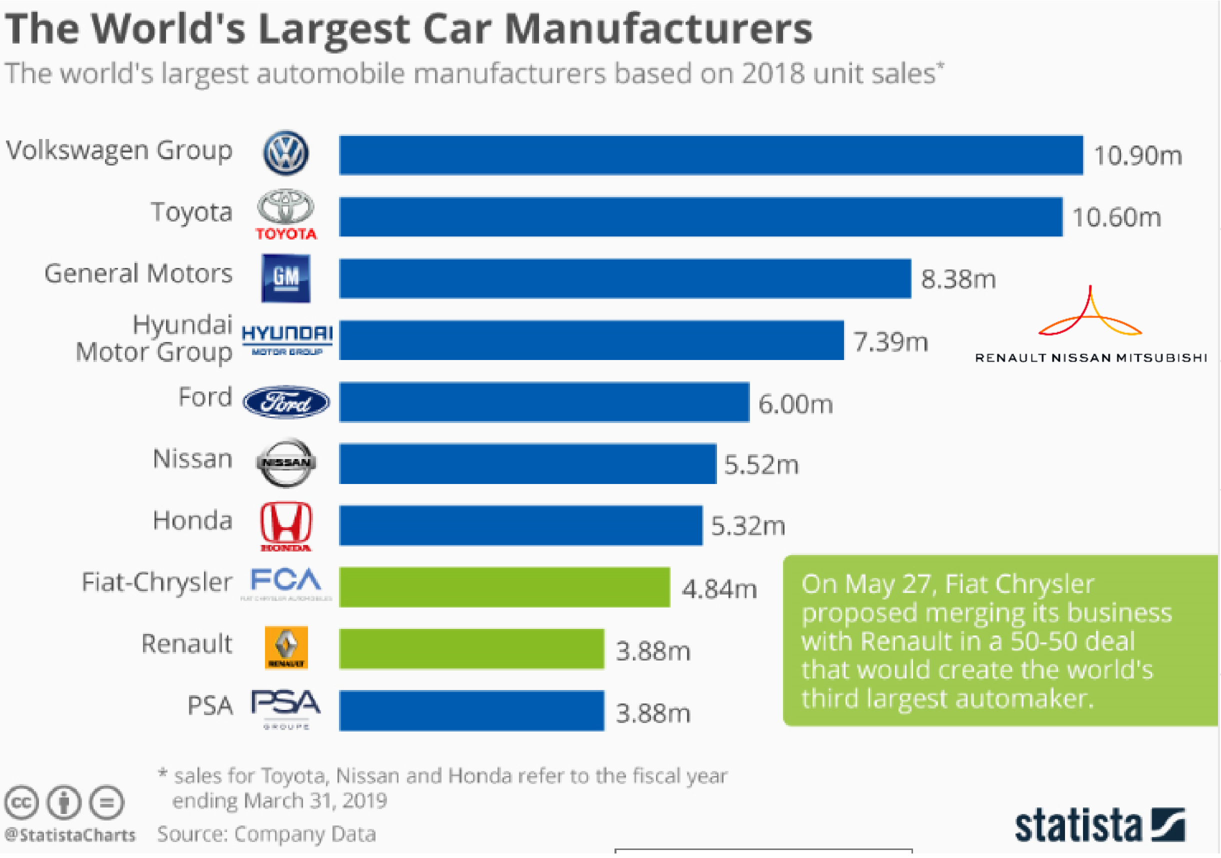
Figure 19. World motor vehicle production



Source: ACEA, 2018

In this previous part of the paragraph we analysed the global offer and demand of motor vehicles, by distinguish among the most important country players. In the next lines the focus is on the major car manufacturer players, based on 2018 units sold. According to Statista that collected the data of car manufacturing companies – **Figure 20.** – in 2018 the world's leading car manufacturer was Volkswagen group, with 10.83 million cars sold, with an increase of 2.2% on 2017, and a turnover of 235,85 billion euro. At the second place we find the Toyota Group, with 10.52 million units sold and an increase of 2,2% compared to 2017. At the third place there is General Motors, with 8.4 million units sold, followed by Hyundai Group (7.4 million), Ford (6 million), Nissan (5.5 million), Honda (5.3 million), Fiat Chrysler Automobiles (4,8 million), Renault (3.8million) and PSA Automobiles (3.88 million). On May 2019, FCA proposed a merge with Renault in a 50-50 deal that would have created the world's third largest automaker. This scenario is even more amplified if we consider the Renault-Nissan-Mitsubishi alliance, one or maybe the longest-lasting cross-cultural automaker alliance, that bring the companies belonging to the alliance to register a total amount of 10.3 million units sold, moving General Motors away from the podium, and placing the alliance on the third place in the global car manufacturers scenario.

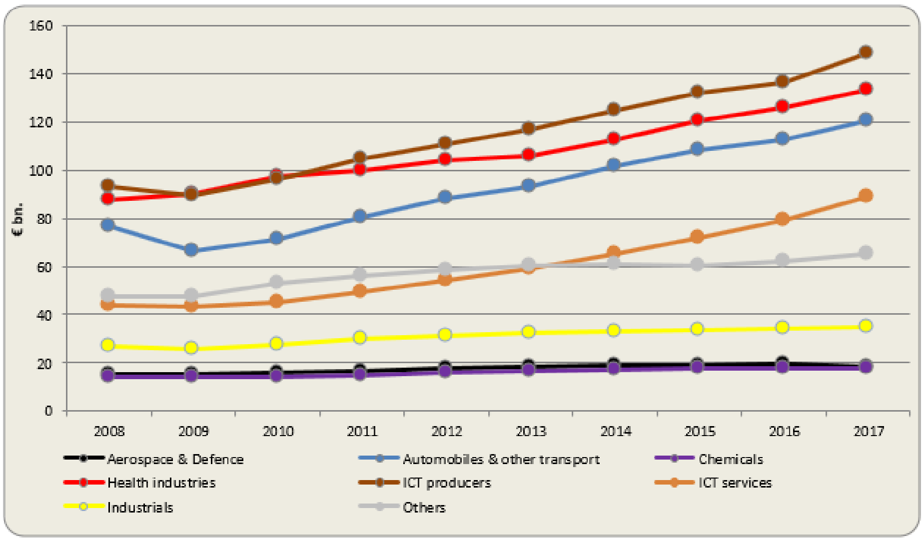
Figure 20. The World's Largest Car Manufacturers



Source: Statista elaboration from Company Data, 2018

For what concern research and development expenditure, a study by the European Commission, the 2018 EU Industrial R&D Investment Scoreboard, provides data on global expenditure divided by sectors. The "Automobiles & Parts" sector ranks among the top three in the world for amount of investment in research and development, preceded only by Health Industries and ICT producers. The **Figure 21.** shows also an upward trend for the above mentioned three main sectors. Within this sector, the ones who spend the most related to total R&D expenditure are Europe and Japan, with respectively 30.5 and 30.8% of total expenditure dedicated to the automotive industry. China spends 11.4% of total national R&D expenditure for the Automotive sector, and USA the 7.8%.

Figure 21. Evolution of the global R&D investment for industrial sectors

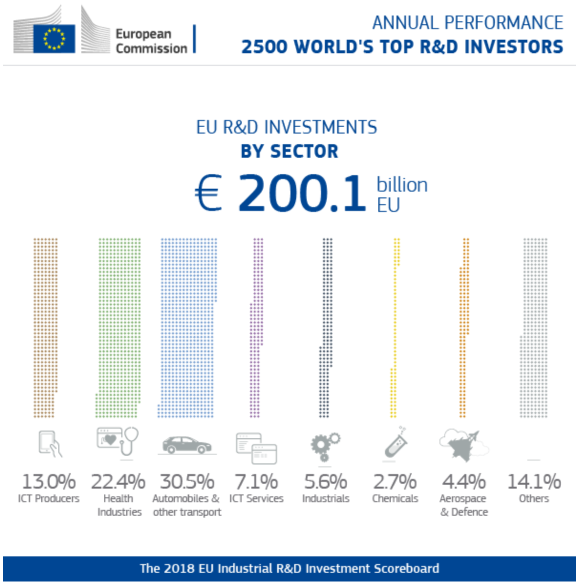


Note: Figures displayed refer only to the 1674 companies (398 EU; 516 US; 326 Japan; 149 China; 285 RoW) with R&D data available for the all period 2008-2017

Source: European Commission, 2018.

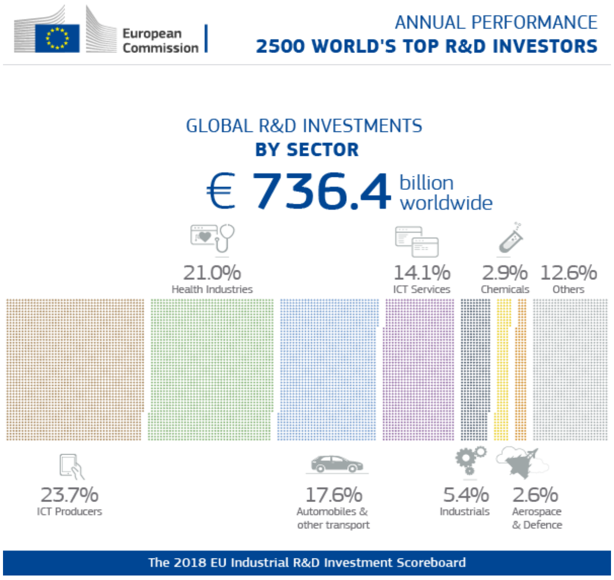
In the specific, global R&D expenditure amounts for 736.4 billion euros worldwide, and it represents the 17.6% of global R&D expenditure (**Figure 23**.). Looking more in detail at the European situation, it is recorded that the R&D expenditure amounts for 200 billion euro, and 30.5% is the percentage regarding the automotive sector (**Figure 22**.). A deep look to this data shows how much importance is given to the automotive sector in Europe – is the sector for which is recorded around one third of the total expenditure in research and development – and the big potential of innovation related to Industry 4.0 that can be exploited by the automotive industry. The automotive industry is the one, among others, that can benefit from the adoption of 4.0 technologies; those radical changes that are connected with the digital revolution can be introduced with a greater impact by the "biggest factory of all", to cite Anderson.

Figure 22. EU R&D investments by sector



Source: European Commission, 2018

Figure 23. Global R&D investments by sector



Source: European Commission, 2018

According to what emerged from the Observatory (2017) in 2018 and 2019 the world demand for motor vehicles was expected to grow respectively to 99.99mln (+2.3% over 2017) and 101.75mln vehicles (+2.8% over 2018). According to forecasts, demand for cars in China will be more contained in the next two years, while the market performance remains good in India (average growth rate around 9%), in Russia, which could exceed 2 million sales in 2019, and in Brazil, which could reach 3 million new registrations in 2019. BMI forecasts growing volumes also in the EU. In the United States, on the other hand, sales are expected to fall slightly in the two-year period 2018-2019 compared to the average volume of 17.8 million in the three-year period 2015-2017. In the EU, demand will be heavily affected by the uncertainties surrounding the circulation of diesel cars and the evolution of regulations at both local and national level, which have an impact on the automotive sector, both on the product portfolio and on prices. The introduction of WLTP certification in September 2018 has repercussions for the entire automotive value chain, as the tariff barriers already introduced and those announced create uncertainties for global distribution and the production network. Demand can therefore change rapidly and remain growing: the renewal of the circulating fleet will be used as a strategic lever, both by producers and governments, to achieve the objectives set in terms of emissions. Light-duty vehicles - cars and vans - account for around 15% of CO2 emissions in the EU. European legislation sets binding emission targets for new fleets of cars and vans, the car industry has invested and worked to achieve these targets and average emissions have fallen each year. The targets for 2015 (for cars) and 2017 (for vans) were already met in 2013. In 2017, on the other hand, average emissions from new cars sold increased for the first time (from 118. 1 gCO2/km to 118. 5 gCO2/km), mainly due to lower sales of diesel cars. In November

2017, the Commission presented a legislative proposal setting new CO2 emission standards for cars and vans for the period after 2020. European CO2 emission reduction standards for passenger cars and light commercial vehicles have so far been a key tool for promoting innovation and investment in low-carbon technologies, but the EU is likely to lose the lead in leading-edge technologies, particularly for zero-emission/low emission vehicles, as the US, Japan, South Korea and China move forward rapidly. China has recently introduced mandatory zero-emission/low emission vehicle quotas for manufacturers from 2019. In the United States, California and nine other states have succeeded in establishing a regulatory instrument to encourage the spread of zero-/low emission vehicles. zero-emission/low emission vehicles are strategic for car manufacturers, given the ongoing announcements and commitments to develop electric propulsion systems and significantly increase their share of world sales in the coming years. The EU automotive industry must aim to become a world leader in these new technologies, a position it already occupies in conventional technologies, given that the automotive industry employs 3.4 million people and indirectly, 11. 3% of the workforce of the European manufacturing sector.

3.1.1 Italian automotive industry

The importance of the automotive industry in the national reality is not only evident from the large amount of trade, the prestige of our brands or their long history: what is also important is the wide supply chain within which the automotive industry is part, generating a significant induced. Vehicles represent a key element in Italian trade flows, constituting one of the first items in terms of both imports and exports.

According to the data collected by ANFIA from the manufacturers, in 2017 the domestic production of motor vehicles recorded an increase of 3.5% with 1,142,210 units, broken down as follows: 742,642 cars (+4.2%), 332,112 commercial vehicles (-3.6%) and 67,456 industrial vehicles (+47%). The volumes of cars destined for foreign countries represent 56% of domestic production. Exports with 742,418 vehicles recorded a growth of 3.6%. Domestic demand and exports also drove domestic production and the automotive industry as a whole in 2017. The positive trend of the national automotive industry as a whole (cars, engines, bodies, components) started in October 2014.

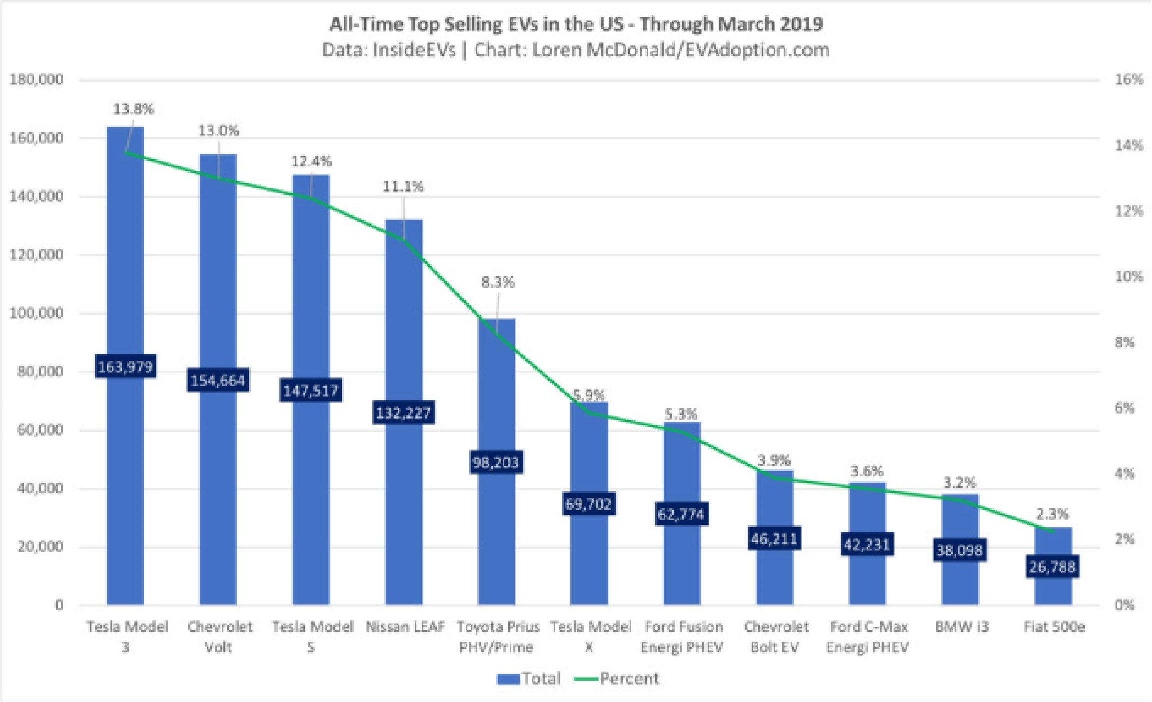
The annual change trend in the production index of the automotive sector grew by 4.4% compared to 2016. The manufacture of motor vehicles (Ateco code 29.1) sees its index grow by 8.3%; the manufacture of bodies for motor vehicles, trailers and semi-trailers (Ateco code

29.2) grows by 12.2%; the manufacture of parts and accessories for motor vehicles and their engines (Ateco code 29.3) grows by 0.5%. Automotive represents in 2017 the 5.6% of GDP of Italy. The turnover of the productive activities (direct and indirect) of the sector is worth 93 billion euros, equal to 10.5% of the total turnover of the manufacturing industry. 46% of businesses remain below €10 million, while 35% are between €10 and €50 million. 53% have less than 50 employees, plus a further 34% of companies between 50 and 250 employees. In 2016 (the latest figure published by ISTAT and EUROSTAT) the national automotive industry employs 165,676 direct employees (4.5% of manufacturing employees), up from 158,914 in 2014 and 160,204 in 2015. For direct employees in the automotive industry, in 2016 Italy became the 7th country in the EU, after Germany, France, Poland, Romania, the United Kingdom and the Czech Republic. With its indirect employees, the automotive industry employs 250,000 people (about 7% of the employees in the manufacturing sector). Although the spearhead of the economy, the car maintains its role as a strategic lever for the system; its complexity makes it an unparalleled manufacturing school and its factories continue to spread welfare and social growth wherever they can remain competitive. The Italian car, then, contains in itself a strategic element for the whole country. In 2017 the investment in R&D amounted for 1.7 billion € for the automotive industry, representing 13.2% of total R&D expenditure (including agriculture and mining) and 18.8% of manufacturing industry R&D expenditure. Vehicles represent a key element in Italian trade flows, constituting one of the first items in terms of both imports and exports. The importance of the automotive industry in the national reality is not only evident from the large amount of trade, the prestige of our brands or their long history: what is also important is the wide supply chain within which the automotive industry is part, generating a significant induced.

3.2 The Green Revolution

For years, the global automotive industry has been investing in innovation and research into increasingly advanced technologies, useful for achieving a continuous reduction in emissions and greater road safety. Low- and zero-emission vehicles, connected vehicles, self-driving vehicles are the new paradigms of the world automotive industry. An evolution in the mobility of people and goods, including vehicles, infrastructure and energy resources, requires a new assessment of how investments and absorption of new technologies are managed and involves new extra-sector operators. Today, we are currently undergoing a green revolution in the auto industry, with more and more consumers making the switch to eco-friendly automobiles from petrol and diesel. In reality, this is not an invention of modern times: the electric car has a long and storied history. Even if it's hard to pinpoint the invention of the electric car to one inventor or country, we can recall it as a series of breakthroughs inventions – from the battery to the electric motor – in the 1800s, that led to the first electric vehicle on the road. In the U.S., for example, the first successful electric car made its debut around 1890 thanks to William Morrison, a chemist who lived in Des Moines, Iowa. He developed a six-passenger vehicle capable of a top speed of 14 miles per hour. Over the next few years, electric vehicles from different automakers began popping up across the U.S.; New York City even had a fleet of more than 60 electric taxis. By 1900, electric cars were at their heyday, accounting for around a third of all vehicles on the road. During the next 10 years, they continued to show strong sales. It was in 1908, when Henry Ford's introduced the mass-produced Model T, that the spreading of electric cars suffered a rapid decline. Model T, compared to its electric rivals, was widely available and affordable. By 1912, the gasoline car cost only $650, while an electric roadster sold for $1,750. Thanks also to the improved development of the American system of roads connecting cities, the decrease in oil prices and the diffusion of filling oil stations across the country, the gasoline car started to substitute the electric car. In the end, electric vehicles all but disappeared by 1935. In the 20 years since the long gas lines of the 1970s, interest in electric vehicles had mostly died down. But new federal and state regulations begin to change things starting from 1990, with the Clean Air Act Amendment and the 1992 Energy Policy Act. During this time, automakers began modifying some of their popular vehicle models into electric vehicles. One of the most well-known electric cars during this time was GM's EV1: instead of modifying an existing vehicle, GM designed and developed the EV1 from the ground up. With a range of 80 miles and the ability to accelerate from 0 to 50 miles per hour in just seven seconds, the EV1 quickly gained a cult following. But because of high production costs, the EV1 was never commercially viable, and GM discontinued it in 2001. While all the starts and stops of the electric vehicle industry in the second half of the 20th century helped show the world the promise of the technology, the true revival of the electric vehicle didn't happen until around the start of the 21st century. The first turning point was the introduction of the Toyota Prius. Released in Japan in 1997, the Prius became the world's first mass-produced hybrid electric vehicle. In 2000, the Prius was released worldwide, and it became an instant success with celebrities, helping to raise the profile of the car. In 2009 Toyota Prius became the Best-selling car of 2009 in Japan, registering 08,876 units sold, a position conquered for the first time by a hybrid model. The combination of batteries and electric motors combined with the traditional petrol engine completely and a decidedly attractive price - about 15,500 euros – contribute to the success of this model. The other event that helped the rebirth of electric vehicles was the announcement in 2006 that a small Silicon Valley start-up, Tesla Motors, would start producing a luxury electric sports car that could go more than 200 miles on a single charge. Tesla Motors was founded in 2003 by American entrepreneurs Martin Eberhard and Marc Tarpenning, and in 2008 released it first car, the completely electric Roadster. This new electric car could achieve 245 miles (394 km) on a single charge, a range unprecedented for a production electric car. Additional tests showed that its performance was comparable to that of many gasoline-powered sports cars: in fact, the Roadster could accelerate from 0 to 60 miles (96 km) per hour in less than 4 seconds and could reach a top speed of 125 miles (200 km) per hour. The lightweight car body was made of carbon fibre. Despite a federal tax credit of $7,500 for purchasing an electric vehicle, the Roadster's cost of $109,000 made it a luxury item, not accessible to everybody like the Toyota Prius did in Japan. In 2012 Tesla stopped production of the Roadster to concentrate on its new Model S sedan, which registered even better performance than its predecessor Roadster. It came with three different battery options, which gave estimated ranges of 235 or 300 miles (379 or 483 km). The battery option with the highest performance gave an acceleration of 0 to 60 miles (96 km) per hour in slightly over 4 seconds and a top speed of 130 miles (209 km) per hour. In 2014 Tesla introduced also the Tesla Autopilot, a form of semiautonomous driving, made available for the first time on the Model S, and later on other models. In 2015 Tesla released the Model X, a "crossover" vehicle. The last car by Tesla is Model 3, the first Tesla electric car thought for the masses. This model has a starting price of $36,000 for the Standard Range Battery. The first 30 Model 3 were delivered in USA on July 2017. Starting from this moment, the Model 3 sales continue to grow until it reached the best global sales of plug-in electric cars in 2018. According to evadoption.com, in February 2019, the Model 3 overtook the Chevrolet Volt to become the all-time best-selling plug-in electric car in the U.S.

Figure 24. All-time top selling EVs in the US

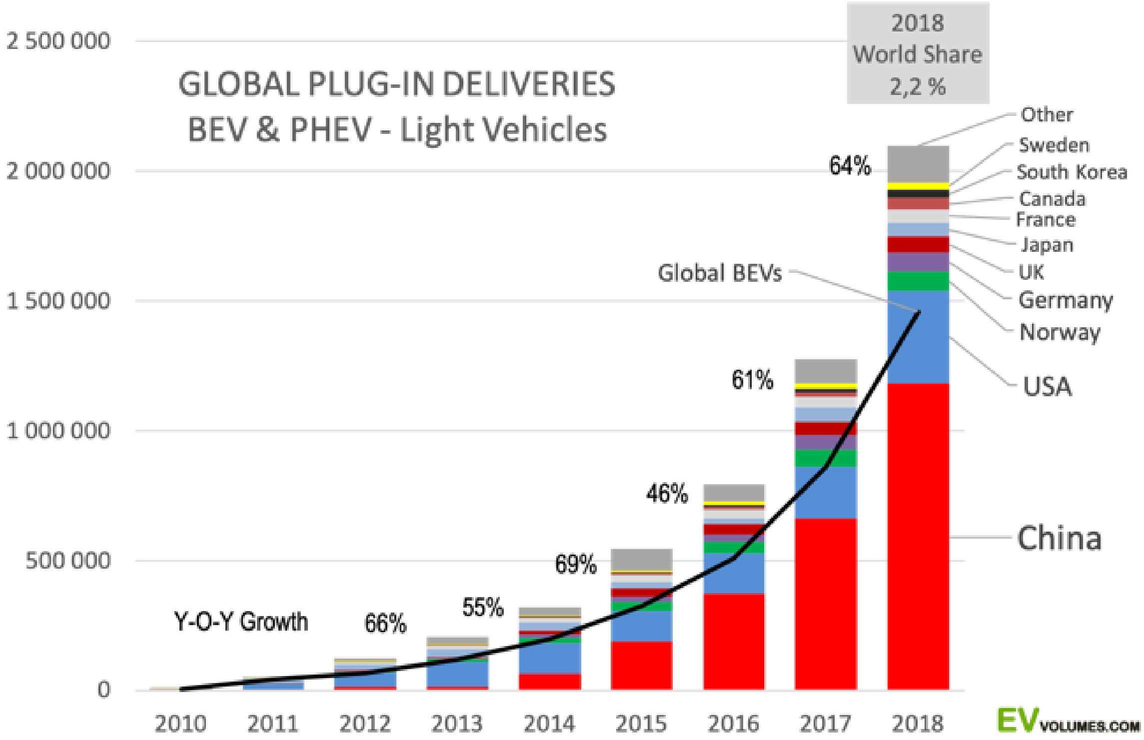


Source: evadoption.com, 2019

As we can deduct from **Figure 24**., among the most sold electric cars in 2019, after the Tesla Model 3, we find the Chevrolet Volt, the Tesla Model S, the Nissan Leaf and the new Toyota Prius, collocating among the best electric car manufacturing brands Tesla, Chevrolet, Nissan, Toyota and Ford.

Looking at the global situation, today consumers now have more choices than ever when it comes to buying an electric vehicle. As reported in the study “100 Italian E-Mobility Stories", promoted by Enel X and Symbola Foundation (2019), currently in the world there are 5.3 million electric vehicles for passengers or goods – were 1.5 in 2016, up by 2 million since 2017 – of which 2 million are in China (+150% in 2018 compared to 2017), 1 million in the United States (+100% in the last year). Only in 2018, sales of electrified cars concerned 2.1 million units (including traditional hybrids). An annual research by EV-volumes, the electric vehicle world sales database, shows the global Electric Vehicles market by countries (**Figure 25**.). The leading country is China, positioning itself as the growth motor of the EV industry, accounting for 56% of total sales, with an annual increase of 520 000, or 78 % more NEVs in 2018 compared to 2017. A curious phenomenon about China is that nearly 96 % of China's EV sales are from domestic production and from domestic brands. The second EV best market is Europe, that reached an overall volume of 409 000 New Electric Vehicles, with an increase of 34% on 2017.

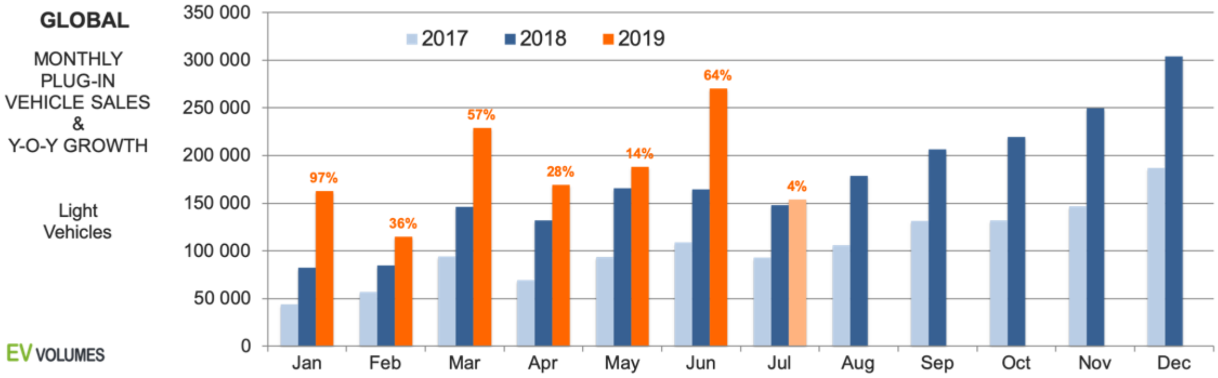
Figure 25. Global plug-in deliveries Bev & Phev - Light vehicles.



Source: evvolumes.com, 2018

Then USA, that registered an increase of nearly 80 percentage point, positively affected by the increase in sales of the new Tesla Model 3. Japan registered a reverse trend, with a decrease of 6%, while some other countries like Canada and South Korea, started to increase at more than expected levels. Globally, the total year-on-year increase of Electric Vehicles worldwide reached 64 percentage point at the end of 2018. It is even more interesting to say that the first data registered by EV-volumes regarding 2019 shows that in the first six months of 2019 – from January to June – there has been an increase in EV sales of 46%, with a volume of 1.13 million units sold, with an increase in China, Europe and USA, and a steady decreasing trend in Japan (**Figure 26**.). The estimation for the end of 2019 are close to the value of 3 million of NEVs sold.

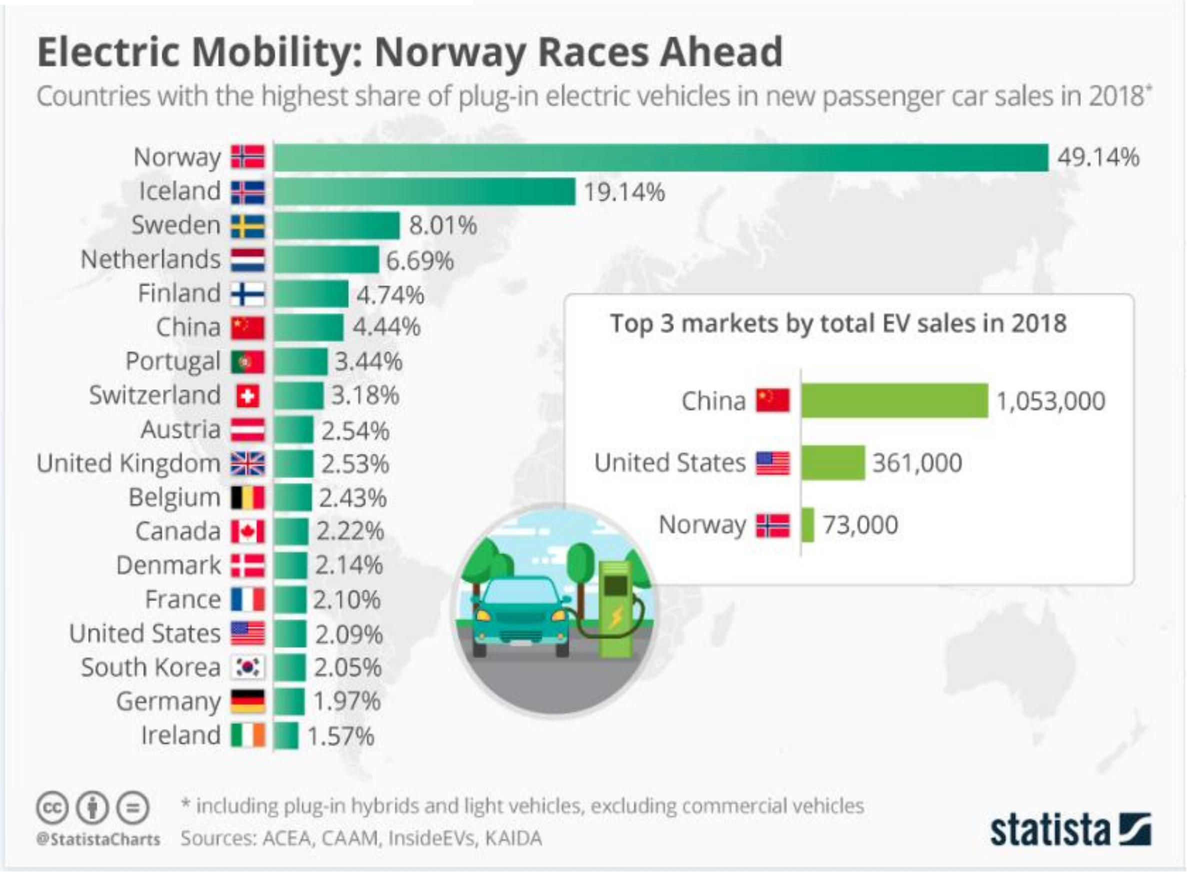
Figure 26. Global monthly plug-in vehicle sales & Y-O-Y growth. Light vehicles



Source: evvolumes.com, 2019

This scenario provides the evidence of a significant growing pace of the Electric Vehicles diffusion worldwide, also considering who are the major and more significant global players. For a more in-depth analysis it is necessary to consider not only aggregate volumes but distinguish among countries the one that shows more significant EV adoption trends. In order to do that, many data analysts collect per-capita EV ownership in different countries worldwide. The World Economic Forum, based on data collected by Statista, made a comparison of plug-in electric car ownership per capita in selected top selling countries and regional markets as plug-in cars per 1,000 people, as of December 2018 (**Figure 27**.). The result shows that the countries with highest per-capita diffusion of EV are Norther-Europe countries. Among them, Norway is the leading country, with 250,000 electric cars and only 5 million inhabitants, and a has a market share of 49.1% of EV on new car sales, registering an improvement by almost 10% from year before, and more than 45% in respect of 2013. The government is striking for the transition to 100% EV's by 2025. At the second place there is Iceland, where 19% of all new passenger car sales in 2018 were electric or hybrid vehicles, while Sweden was third with 8%. At the following place the Northern-Europe Netherlands and Finland register respectively 6.7% and 4.7% of EV new car sales. China, that is the global leader in terms of overall amount of EV sold, in the per-capita analysis falls at the sixth place, with a percentage of 4.4 points. After China there are a list of other European Countries, in order: Portugal with 3.4%, Switzerland with 3.2%, Austria, UK and Belgium closely around 2.5%, then there is the place of Canada, with 2.2%, Denmark, France and USA with around 2.1% and at the last places we find South Korea, Germany and Ireland. Even in this case, USA register a completely different position in respect to the overall EV sales data, not per-capita weighted. This analysis from a different perspective underlines the importance and broad diffusion of the EVs within the EU countries, also motivated by the large incentives and important regulations that are positively affecting European citizens' habits and awareness.

Figure 27. EV shares per Country

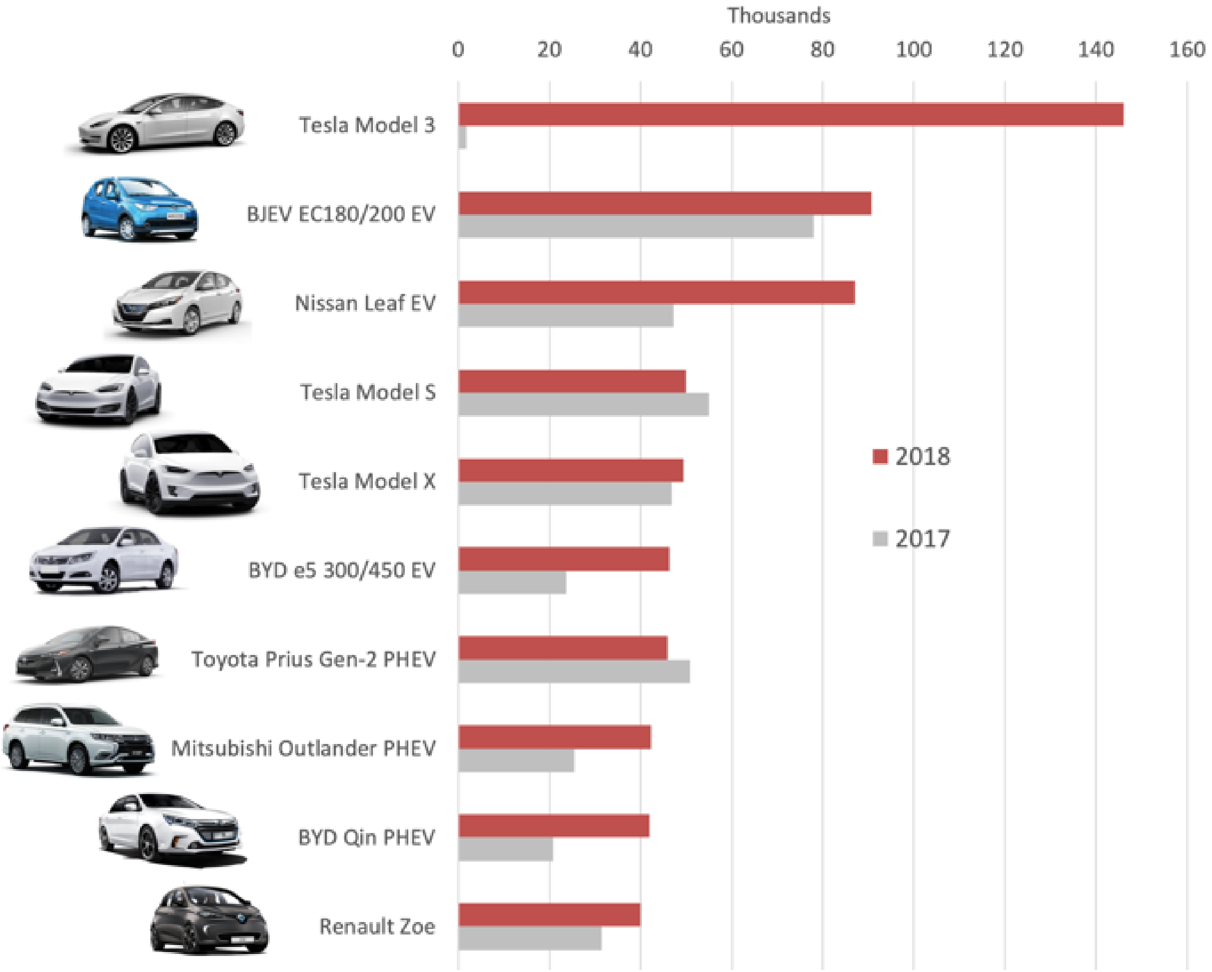


Source: Statista, 2018

EV-volumes concentrated his research also on the best-selling models world-wide (**Figure 28**.). In 2018, as expected by the data shown before in this paragraph, the world's best-selling electric car was the new Tesla Model 3, with nearly 146,000 sales, despite the selling in high volumes started just on the second half of the year and only in USA and Canada – its launch in Europe was only in 2019. Tesla has all three of its models in the top-5 of the global ranking, even if the growth in sales of the two older Model S and Model X were close to 0 in 2018, with deliveries of nearly a quarter million electric vehicles worldwide, of which 191,000 in the US and nearly 30,000 in Europe and another approximately 17,500 in Canada with the remaining 6,500 mostly going to China. The best-selling car of 2017, BAIC EC180, loose position in the worldwide scenario probably due to a battery upgrade, but it remains the first electric car sold in China. The Nissan Leaf Gen-2 is at the third place, with 87,000 units sold and an increase in sales of 84 % compared to 2017, even if they lose their position as the world's largest producer of electric cars. At the fourth and fifth place there are the already mentioned Tesla Model S and Model X. The sixth top model is the BYD e5, that grows its sales mostly in China. Toyota Prius

Gen-2 come strictly after but registered a decrease in sales compared to the 2017, mostly due to the decrease of sale volumes in Japan. At the last three places we find the Mitsubishi Outlander, the BYD Qin and the Renault Zoe with nearly 40,000 deliveries each one. The top-10 electric vehicle models stood for 30 % of the global volume in 2018.

Figure 28. Top ten EV models - Global sales

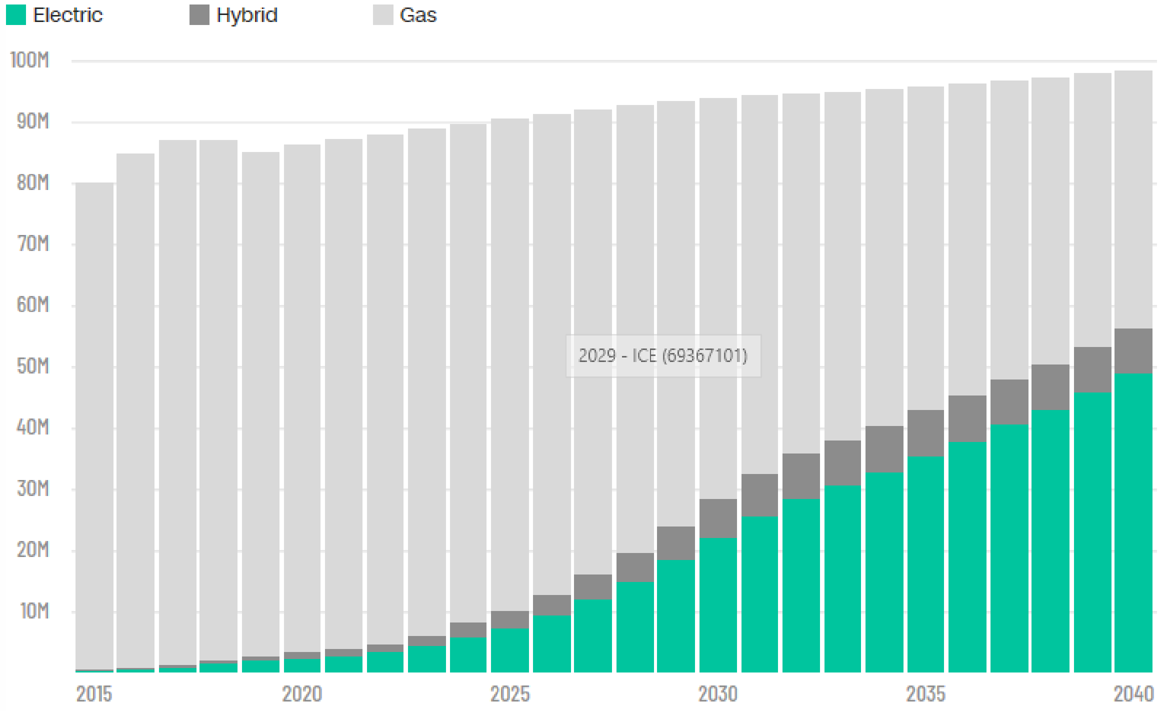


Source: evvolumes.com, 2018

The growth of the EV market has also affected the public mobility sector: today about 20% of the global bus fleets are electric, with Chinese cities leading this trend with 99% of the world stock.

Sales in Italy are also on the rise: from 5,000 units in 2017 to about 10,000 in 2018. All car manufacturers are committed to this front: is estimated that by 2030 they will invest about 300 billion dollars. Moreover, analysts at Bloomberg New Energy Finance (2016) have predicted that 20 years from now, more than half of new cars sold will be electric (**Figure 29**.).

Figure 29. Electric and Hybrid Vehicles Growing Expectations



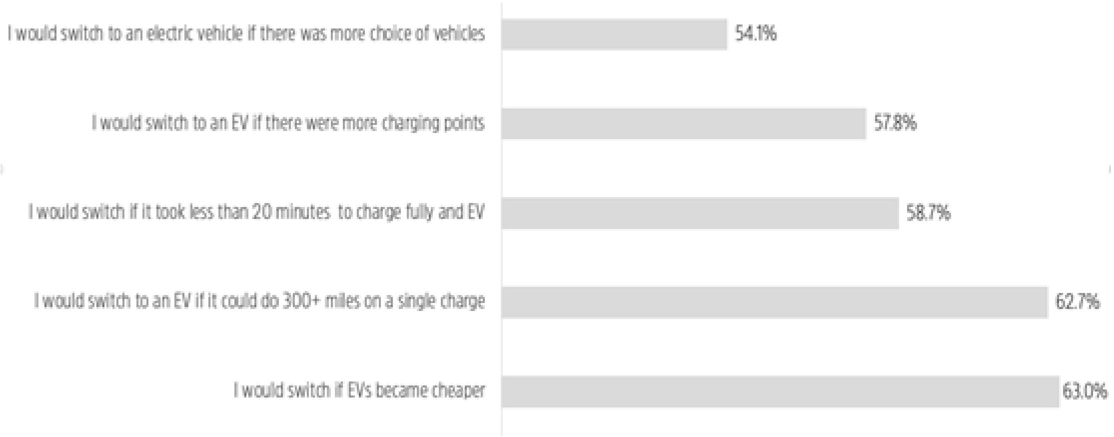
Source: Bloomberg, anno

Those positive expectations regarding electric vehicles are also confirmed by moves made by major companies to invest in their electrification manufacturing. For example, Dyson has just announced plans to set up a manufacturing base for electric cars in Singapore, with the site being completed in 2020, and the first cars launched in 2021.

Research recently published by motors.co.uk (2018) also showed that 20% of in-market car buyers expect to opt for a hybrid for their next vehicle, compared with 19% saying they would opt for diesel (**Figure 30**.)

Petrol continues to be the most favoured next car choice of 57% of buyers though, while electric only accounted for 5%. Even if just 4% of respondents in the survey currently owned hybrid vehicles, this was expected to increase in the next replacement cycle. “With diesel registrations down by nearly a third in the year to date, our findings show how hybrid, rather than electric, is perceived by buyers as a viable alternative and will see the greatest level of growth when they come to replace their current cars,” said Dermot Kelleher, Motors.co.uk’s director of marketing and business intelligence. The survey also identified cost, range and an insufficient recharging infrastructure as the main limiting factors to fully electric cars.

Figure 30. Barriers to adoption of EV



Source: motors.co.uk, 2018

Nearly two-thirds of buyers (65%) felt EVs were too expensive compared to traditional fuel types, with 63% saying they would switch if they became cheaper. In addition, nearly 63% said they would switch if EVs could run for over 300 miles on a single charge, 59% said they would switch if it took less than 20 minutes to charge, 58% are willing to switch if there were more charging points and 54% asks for more choice of the vehicles. This research proves evidences that, even if we are currently undergoing a green revolution in the auto industry, for electric cars to really go toe-to-toe against gasoline-powered cars, a few things need to happen first:

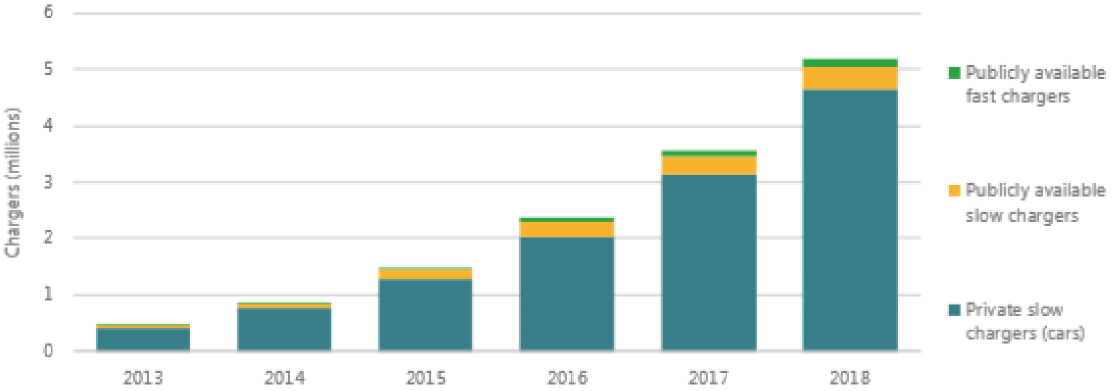
- *Going the distance*: First, electric cars will need to go further on a single charge, and they will need to charge faster;
- *A different mindset*: Car shoppers will also need to think differently about "fuelling" their car, considering that people won't buy electric cars unless they feel they can make an occasional long cross-country trip without worry.
- *More choices, better prices*: Beyond that, there simply needs to be more electric vehicles for consumers to choose from.

Both advanced countries and emerging and developing countries will support the low- and zero-emission vehicle market and, if they are vehicle producing countries, their own industry with short and medium-term plans for the development of electric vehicles.

The State plays an important role in the diffusion and establishment of an efficient network of EVs. Usually it is necessary to establish a set of specific targets. An EV deployment plan often includes procurement programmes to stimulate demand for electric vehicles and to enable an initial roll-out of publicly accessible charging infrastructure. Policymakers must give an important role especially to fiscal incentives, as long as EVs purchase prices are higher than for other vehicles, and promote regulatory measures that boost the value proposition of EVs (e.g. waivers to access restrictions, lower toll or parking fees) or embedding incentives for vehicles with low tailpipe emissions (e.g. fuel economy standards) or setting zero-emissions mandates. Another fundamental role is played by policies that have the objective to support deployment of charging infrastructure, that are the minimum requirement to ensure EV spreading and inter-operability of various types of charging infrastructure: readiness in new or refurbished buildings and parking lots, and the roll-out of publicly accessible chargers in cities and on highway networks.

Focusing of the issue of charging infrastructures, the number of charging points worldwide is estimated at 5.2 million (end-2018), up 44% from 2017 (**Figure 31**.). Most of this increase was in private charging points, accounting for more than 90% of the 1.6 million installations in 2018. Publicly accessible installed fast chargers numbered 144 000 and slow chargers numbered 395 000 by end-2018 (IEA, 2019).

Figure 31. Global installation of electric LDV chargers, 2013-18



Source: Global EV outlook, 2018

Policymakers continue to have a major influence on the development of electric mobility. In recent years, investments have been supported by the state through incentives or emission-based taxes to guide motorists' purchasing decisions.

Moreover, technology developments are delivering substantial cost reductions. Advances in technology and cost cutting are expected to continue. Key enablers are developments in battery chemistry and expansion of production capacity in manufacturing plants. The dynamic development of battery technologies as well as recognition of the importance of EVs to achieve further cost reductions in the broad realm of battery storage has put the strategic relevance of large-scale battery manufacturing in the limelight of policy attention (IEA, 2019).

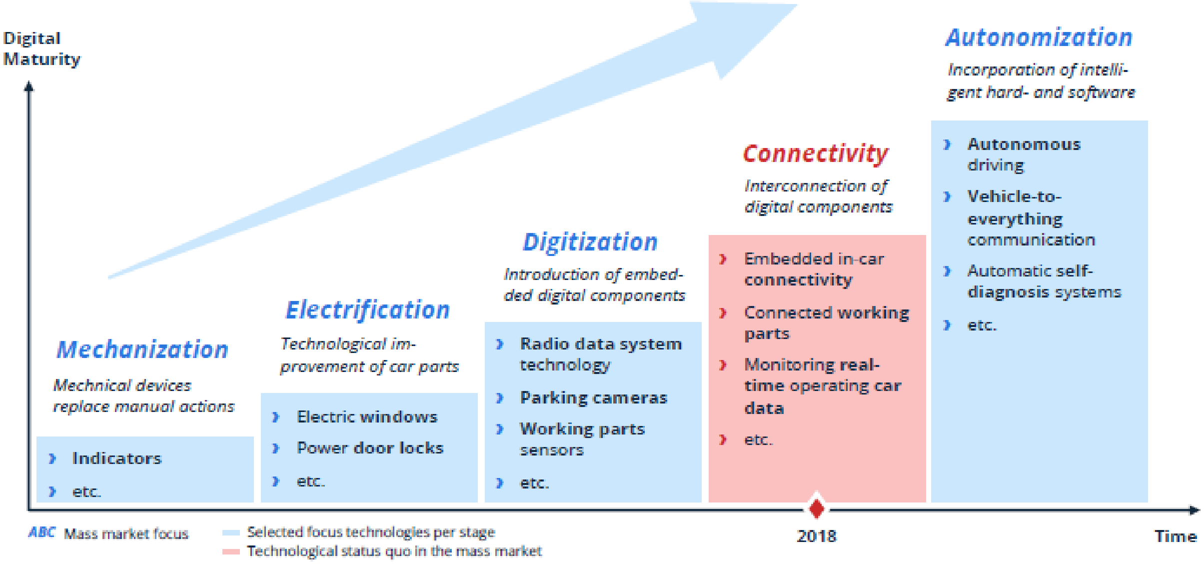
Following this line and considering the data that shows an important positive trend, seems reasonable to expect that the EVs market will continue to grow along with available infrastructures and environmental benefits that are strictly related to electric cars diffusion.

3.3 The Smart Automobile

The automotive market has gone further and further through new technologies, focusing not only on the electric but also giving great space and importance to the spread of the Smart car. The automotive industry is leading the change by investing significantly into new technologies, by collaborating with government and policy makers and working closer by brand together than ever before across different sectors. This allowed the creation of the smart car, a car that can have the characteristics of a self-driving car and those of a connected car. It is a vehicle capable of combining the potential of the self-driving car and those of the connected car. And, therefore, it represents the greatest challenge for car manufacturers, who are increasingly attracted to this reality. When we talk about the cars of the future, in addition to referring to the electric car, we also refer to the smart car.

The smart car, first of all, can be a *self-driving car,* whose level of automation can be of grade 4 or 5: in the first case it is a substantially high independent driving, in which the vehicle can perform all the critical safety functions and constantly monitor the road conditions for the entire journey, but not in extreme weather conditions; in the second case, instead, only the indication of the destination and the start of the system is required, without further intervention by the driver, in all possible cases. Self-driving vehicles with (inactive) driver and without driver can revolutionise the transportation system by changing products and customs. It's hard to tell if they'll be a reality in 10 years or 30 years or more. The transition to an autonomous transport system has many difficult nodes to solve, that requires time and work. The majority of the issues are related to technical uncertainties for a new technology (risk of sensor failures, danger of hackers and privacy risk for data communication), the quality of infrastructure, the risk that excessive use of these vehicles can increase urban traffic and, above all, civil liability on the road, the adherence of consumers/citizens to this model of mobility, the security of millions of data and information. In addition, self-driving vehicles require legislative intervention both in the initial phase, to make it possible to experiment, and also in the reformulation of a regulatory framework regarding civil liability and the insurance problems that can arise. In Italy, the green light for road testing of self-driven vehicles without the active intervention of the driver was given only in April 2018 (Osservatorio Automotive, 2018). But if on the one hand the implementation of the self-driving car requires more experimentation and time, on the other hand the technologies related to the connected car are already spreading since few years ago. According to the Connected Car Market Report of Statista (2018), the Connected car is considered to be the predecessor of the Autonomous car, the step before in the technical evolution process (**Figure 32**.). The Connected car came after the periods of Mechanization, Electrification and Digitalization: in this phase we assist to the interconnection of the digital components embedded in the car alongside with the real-time operating data monitoring. The next, big, step is the incorporation of intelligent hardware and software in order to obtain autonomous driving.

Figure 32. Gradual automotive development towards autonomous vehicles



Source: Connected Car Market Report, 2018

The Age of Connected Car began in 1996 with General Motors' introduction of Onstar, the first wireless, in-car driver assistance system. Twenty-one years following Onstar's release, we are seeing a literal metamorphosis of the auto industry, with the transformation of "automotive companies" in "connected car technology companies". The connected car is developed starting from the IoT (Internet of Things), which now pervades any area of everyday life: it has a touch screen, apps, allows you to communicate, listen to music, share information on social networks, is equipped with the computing power of 20 computers, can process up to 25 GB of data per hour, the equivalent of 4 HD movies, and over 100 million lines of software. The smart car differs from conventional cars in two main features: first, it is configured with a dense network of sensors that control every functional aspect of the vehicle, the mechanics, electronics, dynamics, safety of the occupants and circulation. Secondly, it is able to communicate outside the information collected by these listening points using the protocols and infrastructures of the Internet network.

The connected vehicles are able to interact with the driver, with other vehicles (V2V - Vehicle to Vehicle) and services (V2X - Vehicle to Everything). The connected car is equipped with a range of technologies that increase road safety and minimize the chances of an accident but also help the driver in daily maintenance and operations. For example, proximity sensors on the front and rear of the car may notice a sudden slowdown in traffic long before we do and start to brake before our foot moves from the accelerator to the brake, avoiding possible collisions. In the same way, the intelligent car is also able to read road signs, such as speed limits, or follow the lanes of the motorway independently. Fitting cars with the ability to measure distances between vehicles and respond automatically to road signals should help to ease congestion as well as reduce traffic accidents. Smart connected cars will have an effect on insurance premiums if research shows that the chances of them being involved in a crash is significantly less than in other vehicles. But the connected car is not only concerned with the health and safety of the occupants: it is also able to take care of itself. The network of sensors with which it is equipped keeps every functional aspect of the vehicle under control, signals any problems to the driver and is also able to communicate them to the manufacturer's service department or to the parent company for software updates, drastically reducing repair times. Not only that: the connected car can send the report on the defective part or that has broken directly to the manufacturer, who can then identify the plant where it was produced, the production batch, the factory where the car was assembled. And if necessary, decide that all cars fitted with the same component should be subject to a prior recall.

The Smart Road. The connected car can also communicate in real time with the other intelligent vehicles moving along the road and with the road itself. Cars, public transport, trucks and vans that move in the same area or along a common line can communicate constantly with each other and provide, for example, drivers with alternative routes that optimize travel times and fuel consumption. The system could propose different routes to those who have to go from one end of the city to the other depending on the type of vehicle, passing through the residential areas only the least polluting ones and confining the others on more external routes. In the same way, the road infrastructure could communicate to the vehicles the optimal speed to keep in order to find green all the traffic lights of the route and thus avoid the formation of traffic jams. This kind of traffic management requires a very robust hardware and software infrastructure, able to calculate and update in real time the navigation parameters of millions of vehicles at the same time, to monitor traffic flows and to choose the most appropriate route for each car. To manage such a large amount of data, it is necessary to use the technologies of IoT and Big Data, such as Watson IoT, the cognitive computing system developed by IBM for the Internet of Things that can handle up to 13 million messages per second.

Infotainment. Thanks to on-board technology, all the multimedia functions available in the car, such as the smartphone, navigation system, TV and DVD playback devices, can be intuitively controlled. Infotainment systems, such as BMW's iDrive, are systems that enable the hybridization of information and entertainment, thus constituting one of those automotive sectors that has undergone the greatest evolution in recent years. The system can be touchscreen or managed through the use of voice commands. Automakers are expected to begin introducing models with AI interfaces in the very next years. The software will be integrated into the automotive infotainment system as a virtual personal assistant that can respond to vocal demands, provide real-time information and guide drivers in conjunction with a smart technology system.

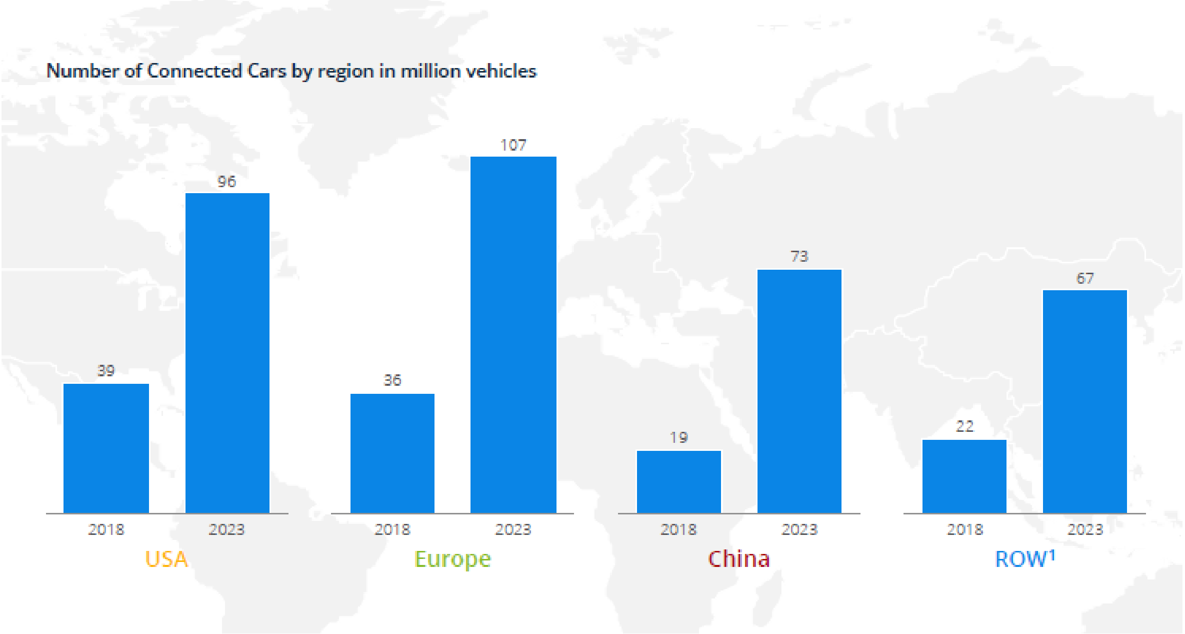
Telematic Box. The telematic box is able to simultaneously detect the position and operating data of the vehicle and to send and receive information from outside thanks to a satellite tracking module, which can perform various functions and applications of tracking, security and info mobility and is able to let the vehicle and the driver access services related to intelligent mobility management. The main potential uses of the telematic box are: insurance services (e.g. ‘black box' insurance), fleet management, tracking, info logistics, carpooling, e-call (automatic emergency call in the event of an accident or tipping over of the vehicle), e-toll (telematic payment of tolls or other road services), tele diagnosis (remote monitoring of the operation of the vehicle that enables a central infrastructure to detect any failures or anomalies) and obtaining information on parking, LTZ, traffic and road conditions.

Advanced driver assistance systems. ADAS are already present in the new generation of vehicles and are the first step toward autonomous drive. These are infrared sensors, cameras and radars that collect data to help the driver in certain driving functions, such as: Adaptive Cruise Control (ACC), Autonomous Emergency Braking (AEB), Adaptive Light Control (ALC), Automatic Parking System (APS), Blind Spot Monitor (BSM), Camera Monitor System (CSM), Cross Traffic Alert (CTA), Emergency Driver Assist (EDA), Lane Keeping Assist (LKA) and Traffic Jam Assistant (TJA). We can consider the ADAS as the first step towards the transition of self-driving vehicles, as they are devices that improve safety, but do not replace or reduce the intervention of the driver, who keeps the active driving of the vehicle.

According to Stratistics MRC, the Global Connected Car Market in 2017 reached a value of 66.57 billion euros and is expected to reach 255 billion euros by 2026 growing at a CAGR of 16.1% during the forecast period. The estimation for 2019 are of 90,8 billion euros – according to Autopromotec. The overall expected increase from 2019 to 2026 will be around 200%.

By 2023 the estimates show that worldwide there will be 343 million connected cars on the road, even more if we consider how governments are moving fast to change regulations that fosters connected car development and diffusion (**Figure 33**.). Today, USA dominates the market, especially due to the rising government permissions and increasing communication & information technology infrastructures. Asia Pacific is the fastest growing market continuing to grow, thanks to connected car devices in passenger cars and rise in digital services such as cyber security.

Figure 33. Number of Connected Cars by region in million vehicles



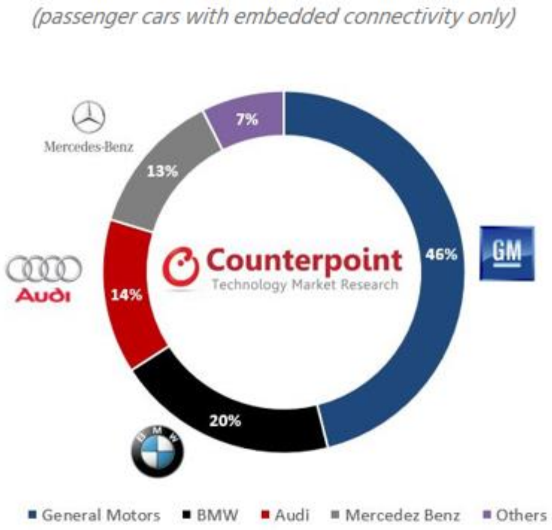
Source: Digital market outlook, 2018

In China Hardware is the biggest connected car segment. Europe is at second place, following USA, but – according to Statista – it is expected to overtake the US in a few years, with a total of 107 million connected cars expected to be on the European roads by 2023.

In terms of overall penetration country by country, Germany, UK and US are leading the market (2018) with highest percentage of total shipments with embedded connectivity sold. Europe's eCall system regulatory act is expected to change the market dynamics with higher penetration across European countries. The adoption of eCall in Europe is expected to create ripples across other geographies thereby catalysing the overall car connectivity ecosystem.

Moving the analysis on the players' side, according to a research by Counterpoint (2017), General Motors is leading the market in terms of number of shipments, followed by BMW, Audi and Mercedes Benz, respectively (**Figure 34.**). The connectivity platforms such as GM's OnStar, BMW's Connected Drive and Audi Connect are offering various services while creating new revenue streams and bridging the gap to stay connected with the consumers. Together, these brands account for more than 90% of the total connected passenger cars with embedded connectivity sold in 2017. A relevant importance has also the other high-tech companies like Tesla and Ford, continuing innovating and adapting their new models to new trends and market developments.

Figure 34. Global Connected Car Shipments % Share 2017 - by Brand

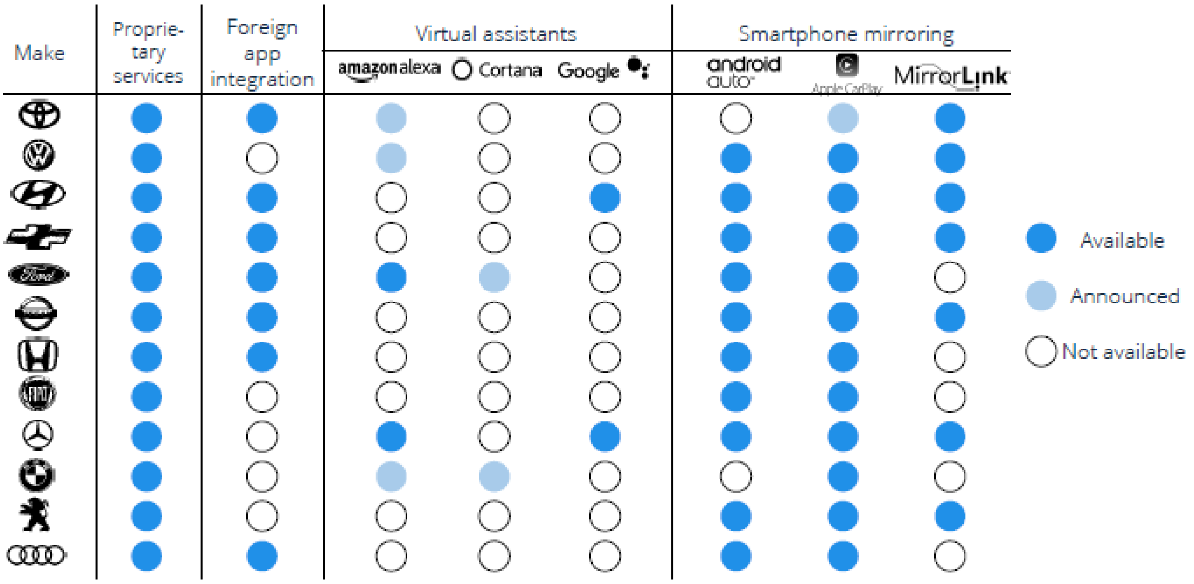


Source: Counterpoint, 2017

The strong future growth of the world market of connected cars will be due in particular to the huge investments in the field of telematic services on board vehicles by car manufacturers, suppliers and new operators in the technology sector. According to the Orbis Research study, connected cars will become a reality increasingly widespread internationally within a few years thanks to the advent of 5G, the new technology for data transmission that is becoming a reality in 2019 and that in the coming years will revolutionize, between other things, even the world of mobility.

Among the top companies that will shape the connected transport industry we can find Google, Apple, IBM, Microsoft, Cisco, Intel and the European giant Robert Bosch. These groups will try to impose themselves with an offer that will touch at least one of the elements of the market - hardware, software and services - and one of the types of IoT's own connectivity of the car: in-vehicle communication, communication between vehicles and communication between vehicle and infrastructure. The applications will be developed mainly on three lines: infotainment, navigation and telematics. In the **Table 4**., by Statista, there is depicted the current and expected situation of the major automotive companies and their adoption of connected services and virtual assistance integration by the major Original Equipment Manufacturers (OEMs). All the car manufacturers already have proprietary services, but most of them planned to implement of have already implemented their service systems with the help of Amazon Alexa, Windows Cortana, or Google Virtual assistance. Some of those companies also provide Smartphone mirroring systems, like Android Auto, Apple Car Play and Mirror link, that allows the smartphone to be connected on the video screen inside the car.

Table 4. Source of connected services offered by selected OEMs



Make	Proprie-tary services	Foreign app integration	Virtual assistants			Smartphone mirroring		
			amazon alexa	Cortana	Google	android auto	Apple CarPlay	MirrorLink
	●	●	◐	○	○	○	◐	●
VW	●	○	◐	○	○	●	●	●
	●	●	○	○	●	●	●	●
	●	●	○	○	○	●	●	●
Ford	●	●	●	◐	○	●	●	○
	●	●	○	○	○	●	●	●
H	●	●	○	○	○	●	●	○
FIAT	●	○	○	○	○	●	●	○
	●	○	●	○	●	●	●	●
BMW	●	○	◐	◐	○	○	●	○
	●	○	○	○	○	●	●	●
	●	●	○	○	○	●	●	○

● Available
◐ Announced
○ Not available

Source: Digital market outlook, 2018

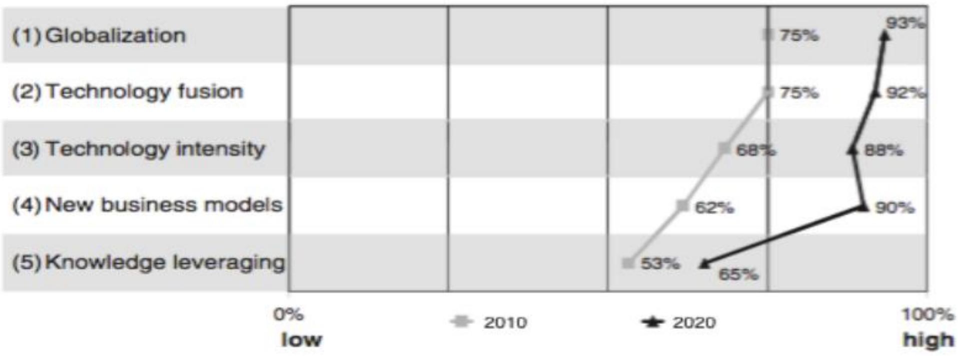
Increase in the demand for safer, more efficient and convenient driving by consumers, rise in industry compliance rules and government authorization for supporting connected technology in passenger cars are the determinant key factors fuelling the market growth. One of the major opportunities in the market is development of the new value chain ecosystem of the automotive industry.

Italy Smart cars. The Observatory of the Internet of Things of the Polytechnic of Milan reported that the connected car market will continue to grow and be one of the pillars of IoT growth in Italy. At the end of 2015, 5.3 million connected cars were in circulation in Italy, one seventh of the fleet. In 2018 Smart Car turned to gain a market that is just over one billion euros (21%, +37% compared to 2017), and can count on 14 million vehicles connected at the end of 2018, more than a third of the fleet circulating in Italy. The most common connection technologies are GPS/GPRS boxes for locating and recording driving parameters for insurance purposes (69%, +14% in 2018), which have been on the market for many years now, but growth is mainly driven by natively connected cars (31%, +69% in 2018): 70% of vehicles registered in 2018 are equipped with a connection system via SIM or Bluetooth since the production phase. The growth of Smart Cars in Italy is driven by some factors such as the introduction - in March 2018 - of the regulatory requirement related to eCall, the system of automatic emergency call in case of accident. Other legal provisions could also affect the sector, such as the black box itself, which could become mandatory by 2022 across Europe: the aim is to make roads safer, but it is clear that the black box is a device that lends itself to multiple uses. For the Observatory, a further stimulus to innovation will be given in the coming months by the increasing integration of smart speakers in cars, allowing users to interact with the car through the voice, through technologies such as Amazon Echo Auto, which can be purchased and installed on cars already in circulation and which is gradually beginning to be integrated in some countries in different car models.

3.4 The New Open Car factory

Automotive 4.0 is the last frontier of an industry that, through a contamination of automation, robotics, information technology and application intelligence, continues to invest and grow in an extremely positive way. Acclaimed Czech author Milan Kundera once stated that, “Business has only two functions - marketing and innovation.” Whilst it may seem a brutally simplistic view, it’s a fair comment regarding most businesses’ fundamentals: to develop and maintain a sustainable competitive advantage and to sell their product to as many of their target market as possible. To achieve this in the automotive industry, a commitment to innovation is essential (Bollo, 2017). Automotive Manufacturers have historically invested heavily in building internal R&D capabilities.

Figure 35. The relevance of each trend and development within the automotive industry

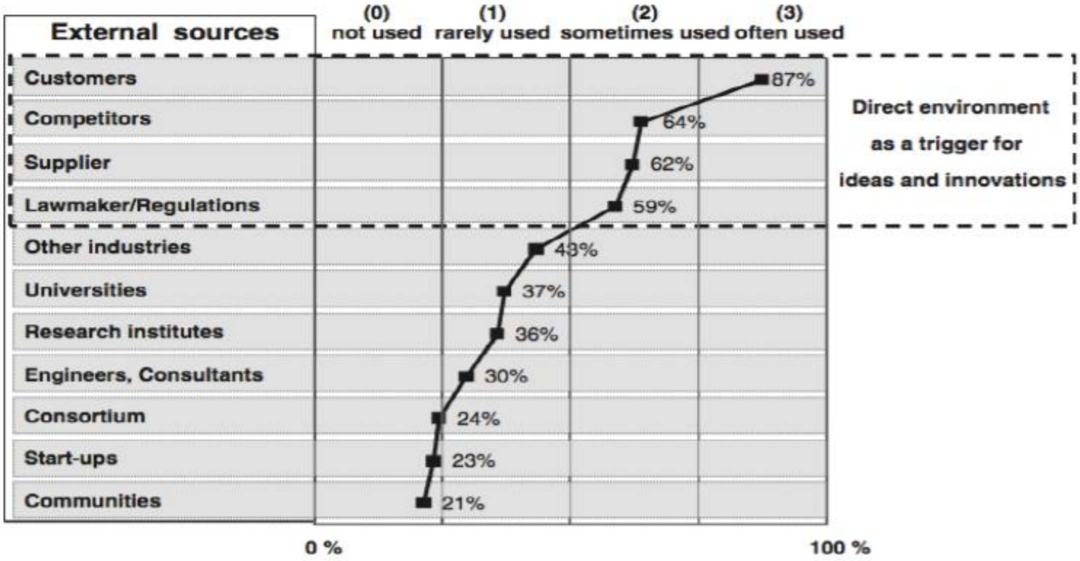


Source: Ili et al., 2010

This has worked until the point where effective innovation has become too complex and expensive for companies to achieve wholly from within (Ili et al, 2010). Innovation become more aggressive due to increasing price erosion and shorter product lifecycles, that way demand innovation to be as dynamic as possible. Adopting open innovation is a potential solution for firms – and automotive firms in this case – to remain competitive in the global industry. The automobile industry is used to be referred as “the industry of industries” – this statement become more realistic if we consider that the average vehicle has in excess of 30,000 components and parts. Every one of them requires innovation – consistently and persistently – such is the demands of this industry. That is why innovation must be open and extra-organizational. Open Innovation is not only the future - it's the here and now, future success in the automotive industry will come from those who embrace it. In order to validate this theory, acclaiming for open innovation to be the most suitable solution for automotive firms in the entire supply-chain to remain competitive, we can cite a Gassmann definition, stating that "the more an industry's idiosyncrasies correspond to developments and trends like (1) globalization, (2) technology intensity, (3) technology fusion, (4) new business models and (5) knowledge leveraging, the more appropriate the Open Innovation model seems to be" (Gassmann O. 2006). Ili, Albers and Miller (2010) based their research on open innovation theories adaptability in the automotive industry on Gassmann definition. As shown in the **Figure 35.**, they demonstrate that Automotive industry already showed the appropriate characteristics in 2010, and it prospected to become even more suitable in the following ten years. The occurrence of the first four trends – globalization, technology intensity and fusion and business models - ranges from 62% to 93%. Only knowledge leveraging of 53% in 2010 and in future 65% is not distinctive: this data showed how knowledge is concentrated on a few experts and this is the reason why it is very important for firms to identify the right people to implement innovation. Online technology open marketplaces like Innocentive or yourEncore could support the automotive industry in this challenge. The importance of increasing technology intensity and fusion implies that integration of external technology as well as intensive collaboration with other industry sectors will become a crucial factor to increase innovativeness. The impressive relevance of new business models in future clearly shows potential for innovative business ideas. The same research identifies the external knowledge sources and external paths to market are currently being used by the automotive industry and which potential benefits the innovation environment (**Figure 36**.). The results show that customers are the most important source for innovation, followed by competitors and suppliers. Governmental regulations are an additional source for innovation. The other sources result to be not so relevant in 2010, but it is also true that in the last years, things may be changed, as the innovation environment someway forced more and more collaborations with external parties for companies to remain competitive.

Collaboration with partners and even competitors has become a strategic imperative for companies, especially for companies in the automotive sector that are suffering from an increasing global competition, also due to the spreading of the new trends in the field of green and sustainability. There are many examples of competing companies which share platforms and flatbeds in the cars' production process, responding to the need of keeping costs down but above all in order to obtain products that meet the needs of the customer. Attention to consumers' needs has also led scholars of these phenomena to pay more and more attention the collaboration of companies with customers for the co-creation of value (Von Hippel). The most used tool in this area is once again the Web, that is considered to be the only tool that allows for the involvement of the end user in the innovative process and once again are the communities online to play a decisive role, allowing companies to enter the market in a social dimension and in the sharing of ideas and interests (Verona e Prandelli, 2008). In today's global economy, organisations are collaborating more and more. Thus, organisations are engaging in new forms of highly collaborative mechanisms and networked structures capable of providing a competitive advantage by combining the best skills or core competencies and resources of two or more organisations, as well as customer knowledge of a product or a service to co-create a value proposition more compelling and relevant to the consumers' needs and expectations (Romero, 2011).

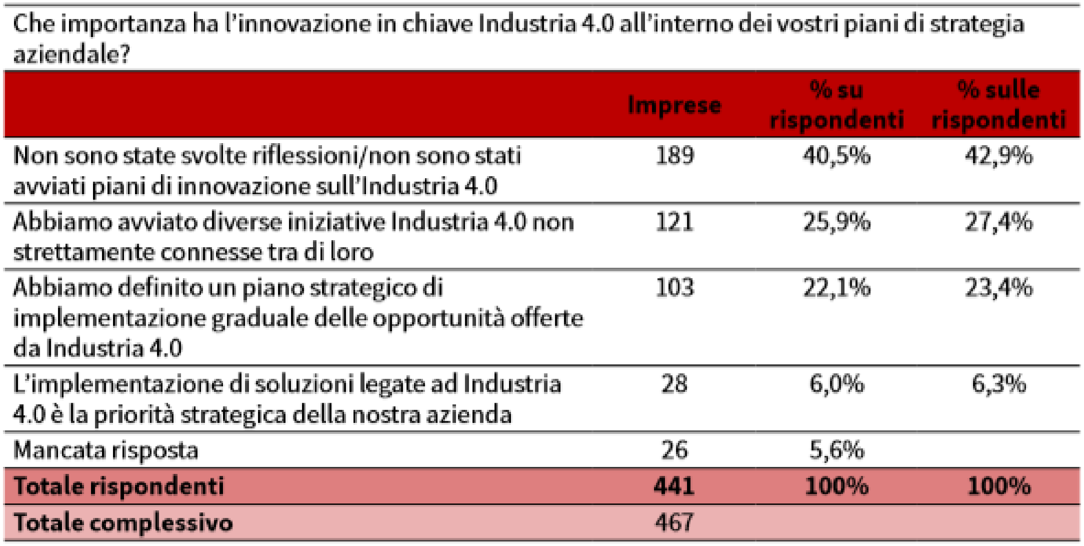
Figure 36. External sources used by the automotive industry



Source: Ili et al., 2010

Moving the analysis to the Italian context, the Observatory studied the diffusion of 4.0 initiatives in Italian automotive companies, asking them two questions: the first aimed at grasping the presence of 4.0 initiatives and development plans within the business strategy and their relevance (**Table 5**.), the second aimed at understanding whether car companies have already made innovative 4.0 investments (**Table 6**.). Of the 441 companies that responded to the survey, 54% said they had launched initiatives in Industry 4.0 and 28.1% of these said they had framed these initiatives in a strategic plan of gradual implementation or, in some cases, priority. At the same time 40.05% of companies have no plans in Industry 4.0 (**Table 5**.). The data therefore suggest that not only pioneer and innovative companies have made the first investments but also the anticipatory majority is moving towards Industry 4.0. If we look at the companies that have already introduced some innovation that can be traced back to Industry 4.0, the percentage is 48.5%. Only 14.3% say they do not want to make investments while 37.2% will do so in the future (**Table 6**.). The combined reading of **Tables 5.** and **6.** shows that companies investing in Industry 4.0 are basically companies capable of understand their long-term strategic value.

Table 5. Strategic relevance of Innovation 4.0 in the automotive industry

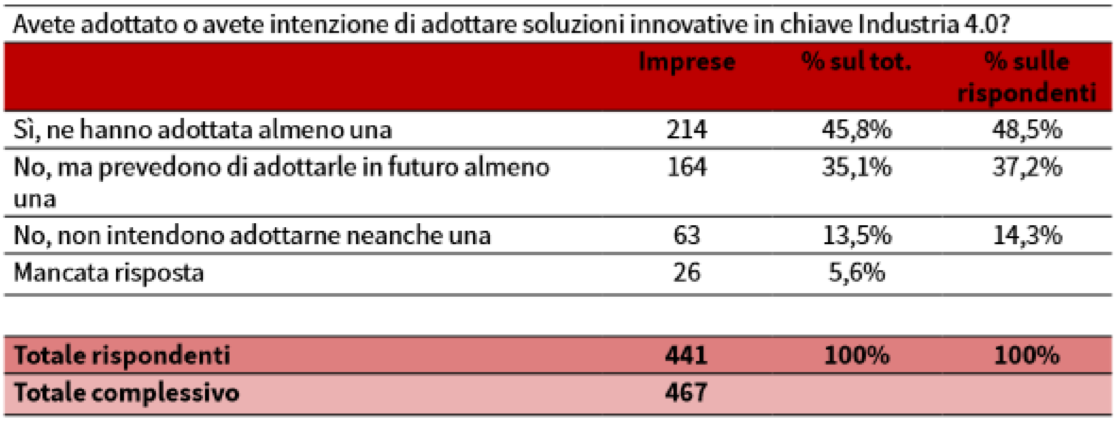


Che importanza ha l'innovazione in chiave Industria 4.0 all'interno dei vostri piani di strategia aziendale?

	Imprese	% su rispondenti	% sulle rispondenti
Non sono state svolte riflessioni/non sono stati avviati piani di innovazione sull'Industria 4.0	189	40,5%	42,9%
Abbiamo avviato diverse iniziative Industria 4.0 non strettamente connesse tra di loro	121	25,9%	27,4%
Abbiamo definito un piano strategico di implementazione graduale delle opportunità offerte da Industria 4.0	103	22,1%	23,4%
L'implementazione di soluzioni legate ad Industria 4.0 è la priorità strategica della nostra azienda	28	6,0%	6,3%
Mancata risposta	26	5,6%	
Totale rispondenti	**441**	**100%**	**100%**
Totale complessivo	467		

Source: Osservatorio componentistica automotive, 2018

Table 6. Innovation 4.0 relevance in the automotive sector



Avete adottato o avete intenzione di adottare soluzioni innovative in chiave Industria 4.0?

	Imprese	% sul tot.	% sulle rispondenti
Sì, ne hanno adottata almeno una	214	45,8%	48,5%
No, ma prevedono di adottarle in futuro almeno una	164	35,1%	37,2%
No, non intendono adottarne neanche una	63	13,5%	14,3%
Mancata risposta	26	5,6%	
Totale rispondenti	**441**	**100%**	**100%**
Totale complessivo	**467**		

Source: Osservatorio componentistica automotive, 2018

The automotive sector shows a propensity to invest in 4.0 above the national average of manufactory industry: about half of the companies have 4.0 plans and invest without recurring at the incentives of the Calendar Plan (incentives of the Italian government in 4.0 technologies, 2016). The results show that the probability of being a 4.0 company is positively correlated to a high position in the supply chain pyramid, to the growth of turnover and to investments in R&D: 4.0 companies belong to the category of the most innovative, dynamic and performing companies. The results of the Observatory also show that the areas most involved in the 4.0 plans belong to the manufacturing tradition of our companies and insist in the Operations area and are, in order, Production, Quality, Logistics and Maintenance. Companies state that the main risks and constraints to the activation of initiatives in the 4.0 field are the cost of the initiative, the ability to assess opportunities and the scarce availability of resources and information. The president of Anfia, Aurelio Nervo, says that among the conditions for automotive 4.0 there are “the overcoming of the size and digital gap of Italian companies, the greater networking of excellence and the requalification of human capital";. Maurizio Stirpe, vice-president with responsibility for industrial relations at Confindustria, said that in the era of Industry 4.0 we need a “contractual model that is never unique", but that has the flexibility to respond to “ different needs and different levels of wealth" between companies, sectors and on the territory in the country. Every different reality must “have the possibility of a tailor-made dress"- And between the social partners, he adds, the contract must increasingly be seen “as a tool that does not feed conflict but sharing principles among industry actors”.

3.4.1 Automotive blog and communities

Consumers are always seeking for real-time, ongoing information sharing and active collaboration. Customer and enthusiast communities are already emerging and beginning to have an impact on automotive innovation. These new and more engaged participants in the product development process are providing input into everything from design concepts and technical expertise to design drawings and technical specifications. Blogs and communities are enlightening the importance of the engagement process, thus allowing companies to reach their committed, involved customers and fuel innovative experiences that can lead to positive outcomes for everyone involved. Members of communities that are also customers or passionate seem to be particularly suitable for the virtual participation in New Product Development (NPD) because of their high product interest and knowledge as well as presence on the Net. To set up an interaction process with these communities it is necessary to consider the particular characteristics of the community like language, netiquette and norms as well as the individual motivation of the community members to share their knowledge and ideas (Fuller et al, 2006). Building a flourishing community is the first step to get back great inspiration and creativity: inside a community a company can get tips on updates and smart features, read how others have solved problems. This is the reason why social monitoring is a great way to understand your customers, what makes them happy or unhappy about your product or service, what they are looking for regarding new product ideas and test out their response to a new product development. Consumer engagement is a powerful way to enhance they loyalty and trust in your company. Online communities have moved on from being a simple tool of social strategy to a full business strategy as business leaders are starting to understand the high-level impact that a connected audience can have on their company's success.

An example of Automotive Social Community is the *Abarth Scorpionship*. The Scorpionship is the only official Abarth community dedicated to car owners, collectors, Abarth club members and enthusiasts. Initially, the community was launched in Italy, Germany, the United Kingdom, Switzerland and France, and then gradually extended to the whole of the Old Continent with a success that exceeded all expectations. The success of The Scorpionship (that register today over 110,000 members), is partly due to the fact that everyone can register freely by filling out the form online on https://www.abarth.it/scorpionship. Joining the community allows, in addition to staying up to date on news and previews, also the opportunity to collaborate with the racing team to support racing teams during the stages of the Abarth Trophy.

DriveTribe is an automotive online community founded by Amazon’s ‘The Grand Tour’ presenters, Jeremy Clarkson, Richard Hammond and James May, in November 2016. The platform features different automotive-themed 'tribes' which people can join, post to, live chat with members of and share content on. The idea of the platform is to have one site for all automotive enthusiasts to share their passions, questions, doubts and interests. Today it counts around 10 million active users that are engaged with the platform on a monthly basis, by posting to it, taking part in live chats with other tribe members, sharing ideas, videos and experiences or playing online quizzes. Millions more are also consuming DriveTribe content on social media every month. As the DriveTribe CEO Jonathan Morris explains, they decide to focus much more on engaged communities and much less on programmatic advertising revenue; this means that clients that are approaching the tribes are very interested in the field they are dealing with. For this reason, the DriveTribe platform was not built with traditional publishing technology but rather technology normally associated with data and financial trading systems. This makes it possible to extract big data analytics instantaneously from the interactions of the engaged customers. This ability comes at a crucial point in history, says Morris. “DriveTribe’s ability to engage audiences and then mine information in real time, comes at a time when the auto industry is going through the most significant change. This includes not only a move from diesel and petrol to alternative fuels but also a progressive move to autonomous vehicles. On top of this, the way in which people buy cars is changing. Large automotive companies are investing in multiple high-risk areas, spending vast sums on research and technology, while realising they need to understand how people think about the changes that are imminent in the world around them”.

Talking about automotive communities, it is important to mention the *Harley Davidson Community*. Harley Owners Group is one of the biggest, or maybe the biggest flagship motor community in the world, managed by Harley Davidson Motor Company. Founded in 1983, today it groups together all the Harley owners and fans from all over the world. It is one of the best examples of what does it mean to build a strong community around a shared passion, with a very tough sense of identity and participation. It encompasses not only people with the same motorcycle, but mostly people that shares the same culture and lifestyle. The Harley Owners Group webpage offers a broad range of online and offline networking opportunities. Firstly, the webpage offers specialized services and products to Harley Owners, ranging from official insurance and financial services to Harley Davidson apparel and touring guides. The webpage is a place where the Harley lifestyle can be celebrated in all its meaning, and every person can share its story, issues, thoughts, advices and more. The community has a marked experiential side, thanks to the promotion of gatherings and events of varying size and scope, which unite members in different locations. Harley community is a powerful way for the company to collect a massive amount of information, such as the shopping habits of members and travel itinerary information, their thoughts concerning Harley products, their expectations and lot of other information.

3.4.2 Automotive industry and co-creation

The ultimate trends in the field of open and collaborative innovation are moving towards a fast-evolving aspect of innovation in the automotive industry we already introduced in this essay – the co-creation. A 2013 study by PwC titled *Looking ahead: Driving co-creation in the auto industry* starts by stating that, "Automotive firms are moving to engage stakeholders like never before using the collaborative power of co-creation". Automotive companies, by using collaborative methods, can provide the opportunity to proactively engage customers, dealers, employees and suppliers. The companies that successfully tap the feedback from these groups can enhance product design, create in-depth customer experiences and increase the effectiveness of their corporate social responsibility programs. Those firms can collect assessments and data feedbacks back from the social media channels of the various stakeholders in the value chain, increasing their competitive advantage.

Longitude and Hitachi made a report in 2017 that founded that companies that are working in the automotive sector are the most likely (83%) to say that co-creation has transformed their approach to innovation. However, the report also found that one of the automotive sector's biggest fears is that the public will start viewing cars as a service rather than as a desirable product. This could be a reason explaining why the sector is moving forward with co-creation: to ensure that they are creating products which are attractive enough as a purchase to consumers. The most significant benefit of adopting co-creation in the automotive industry is that car makers can collaborate with consumers to source and test designs. In fact, the report found that half of automotive organisations said they have worked with consumers on a collaborative creation project on a regular basis. By asking for their opinion, car makers are bringing their consumers into the design fold, giving them a real and vested interest in the final product and making sure that their products remain as attractive and appealing as possible.

In addition, co-creation methods can be used internally to build relationships within the organization. Companies are implementing interactive engagement platforms to collaborate and receive feedback from their employees, to implement their ideas, thus resulting in an increasing in the employee morale and fostering of an innovative culture throughout the organization. Internal collaboration and employee innovations Co-creation can be a useful tool to build relationships within an organization. Establishing the right interactive engagement platforms to reach out the employees can be especially powerful as part of internal change programs, or as a way to foster an innovation culture throughout the organization. When companies really engage their employees and not only ask for their ideas, but also implement them, employee satisfaction and morale go way up. And since satisfied employees are more productive and less likely to leave the company, there's a direct impact on the bottom line. An example of internal collaboration is given by the World Class Manufactory methodology implemented by FCA: one of the main powerful characteristics of this organization tool is that it provides people involvement, at all level: employees are considered an important resource from the bottom, their advices are collected and implemented and the best internal ideas are rewarded.

New technological tools and resources can take internal collaboration to an entirely new level. But those tools are not enough to guarantee a performative strategic internal collaboration. Automotive companies also need to listen to the voices of employees who will actually use these tools in their day-to-day interactions. Indeed, collaboration tools work best when they are co-created with employees. Implementing new HR systems to streamline time reports, for example, can potentially save companies a lot of administrative time. But they need to make sure that systems work well for employees. That's easier if staff is included in the development process. There are many other ways to co-create with employees. With many companies now operating with a smaller staff, looking to every employee as a possible source of new ideas and information can make the difference between surviving and thriving.

The future of the automotive industry is full of challenges and opportunities. The technological revolution spurred on by the Internet of Things era is capable of turning the challenges into opportunities. However, manufacturers must be willing to engage in conversations with other organisations, consumers and governments in order to secure their place in the transition towards smart transportation. In the following lines we will have a look on some representatives of the major car's manufacturers in the world and how they introduce co-creation and crowdsourcing initiatives along their business models.

Germany's Volkswagen - in English the 'people's car,' – opened up an open innovation context in 2011 in China: they introduced the '*People's Car Project*', a long term co-creation interactive platform that collect ideas from customers to ideate, design and build new cars (**Figure 37**.). According to the Design Director of Volkswagen China, Simon Loasby, to make a car "you have to understand the people."

Figure 37. Volkswagen People's Car Project

Source: Volkswagen, 2011

The official website received over 35.6 million views, nearly 13 million visitors, more than 200,000 design submissions, and the followers of its official micro blog topped 495,767. This open-innovation platform has activated a nationwide dialogue about future mobility. With the People's Car Project, the Volkswagen brand became the "most digitalized auto brand in China." (PwC). Volkswagen turned three of the ideas into concept cars and launched them at the Beijing Auto Show in May 2012:

- *Music car*: a car born on the base of the beetle and covered with LEDs that change the body colour according to the music reproduced in the cockpit;
- *Hover car*: a prototype a little far from reality, which includes a two-seater electric circular machine that collects energy from an innovative system of electromagnetic networks;
- *Smart key*: a small 9 mm accessory with a touchscreen that can interface with on-board data and provide information on traffic, weather and geolocation.

Audi introduced the Co-creation initiative first in the 2004, and then in 2006 with their project *Audi Virtual Lab 1* and *Audi Virtual Lab 2*; those projects were conducted in Germany, Japan and in the US. The two main objective of the project were to (1) deliver information about customer expectations, preferences and upcoming trends in the Infotainment world quickly, cheaply and interactively; (2) give insights concerning customer acceptance, perceptions and input quality of web-based customer integration in NPD in general (Füller et al., 2006). Overall more than 7.000 customers participated in the co-development of the Audi in-car multimedia system. Automotive infotainment systems combine electronic systems such as radio, sound, navigation, phone, display, antenna, interfaces and control. A major challenge for Audi was to design a system able to reflect the ideal combination of information, communication and entertainment elements for the different customer groups of the offered car models. The customers were called to give their ideas regarding the development of future infotainment systems for the models Audi A3 and Audi A4 building up on the experiences made with existing high-end infotainment solutions. "In order to allow consumers to talk about a product they were not able to experience so far, we offered a virtual prototype which allowed the participants to get familiar with the planned infotainment system and then state their actual wants, needs and ideas. Manifold findings and information were gained with help of the Virtual Lab" said Michael Bartl, from Audi R&D division. They identified preferences regarding features and feature combinations for the future infotainment system and grouped them based on Audi models and other data like demographics and consumer traits. This process allowed easily to change development specifications in the early development stage without losing a great amount of time and money based on already invested development efforts. The most interesting thing was to realize how highly involved and motivated were the customers that participated to this project. It is recorder that most of them spent between 20 and 45 minutes on the platform, for receiving back just some baseball caps and no additional incentives. Moreover, half of the contacted participants of Virtual Lab 1 also took part in the Virtual Lab 2 although 2 years were in between. In both Labs about 80% of the participants expressed interest in taking part in future virtual development projects not restricted to infotainment systems. This indicates the enormous potential to also re-engage users for innovation activities more frequently and maybe to set up innovation panels which rarely exists today, creating a sustainable network based on customers fidelization.

Ford implemented an interactive customer Web site, *The Ford Story* (www.thefordstory.com), that allows customer involvement. Inside this website there is a "*Your Idea*" platform, in which customers can write down their ideas and technologies they believe that can fit in the automotive space: this platform received ideas from more than 3.000 customers. The pilot session of "Your Ideas" gives consumers the ability to participate in a community-based setting where they could review, and rate posted ideas and track what people think about their own suggestions. Ideas that receive the most "thumbs ups" from viewers will be elevated to a most-popular idea list and reviewed by Ford's Advanced Product Marketing and Planning teams. The "*Your Ideas*" forum covers many automotive fields, ranging from vehicle connectivity, comfort and convenience to fuel economy to performance and safety. Through this initiative Ford tried to engage customers going beyond traditional consumer market research, studies and focus groups. Ford understood the importance of adopting the social Web as an innovative way of generating new vehicle feature ideas customers really want and value.

Ford has also opened its doors wider to suppliers. In 2008, Ford created the Joint Technology Framework, which provides designated suppliers special access to Ford intellectual properties so they can develop products for future commercial use. As a result, Ford is making significant progress in several key automotive research areas, including ultrasonic welding, alternative bonding technologies and new processes for reducing wheel weight.

"Automotive is a wonderful place to innovate, there is a lot of technology involved in every process from designing to manufacturing". The statement comes in February 2014 from Nancy Gioia, Director of Electrical, Connectivity and User Interface in Strategy and Planning department at Ford Motor Company.

Fiat – belonging to the FCA group - launched for the first time a crowdsource project in August 2009: "*Fiat Mio*". The main purpose was to invite people to ideate the car of the future and design the world's first crowdsourced car. The Fiat Mio was unveiled in Sao Paulo Auto Show in October 2010: many developments and design of the car were developed by enthusiastic contributors who were interacting with the company through the project website. More than 17,000 participants from around the world provided in excess of 11,000 ideas and solutions.

Fiat Mio is the biggest but not the only crowdsourcing initiative of Fiat. In 2007, 500 days before the launch of Fiat 500, the company invited potential buyers to a web site to design accessories for the car. Thanks to this initiative, more than 8000 potential customers could participate to the process of collaborative generation of the value proposition by providing their creativity and skills. Now there are over 100 accessories that customers find relevant and appealing available. The most popular is a clear glass roof, the second one is Italian colours as racing strips. Customers were also asked to generate the themes for advertising. They were also allowed to customize the look and feel of their own website. It enables customers to get the information that is meaningful to them—front row and centre. Customer involvement helped sell 57,000 cars in the first month (July '07). The Fiat strategy is an example of what can be accomplished by intelligent crowdsourcing of a firm's product development activities. Rather than relying solely on internal abilities, one can think about connecting to a large community of engineers, start-ups and other partners to circumvent the restrictions of limited resources and knowledge and think outside the box, literally.

The German automaker Mercedes-Benz celebrated its 125th anniversary in Singapore with a "*First Thoughts*" contest to commemorate the invention of the first automobile and stimulate future developments. Participants were asked to provide innovative solutions from different backgrounds to the company. The winner was Heng Ming Yuan, with a revolutionary idea of solar cells for the roof, suggesting that cars' roofs can be used to charge batteries or capacitors to allow the driver to start the engine or run the electronics in a hybrid car.

In 2017 was implemented a collaboration with Mercedes-Benz, Deloitte and BeMyApp that results in the *Mercedes-Benz Digital Challenge*, the first contest of its kind to bring together software developers from around the world to build apps using car APIs (Application Programming Interfaces) for a connected car. With over 2000 interested registrants to the competition, almost 500 projects created, just under 100 submissions and over 135,000 API requests this innovation context shows the potential of customers and developers in general when collaborating with automotive firms. By opening up the contest to developers from all over the world they receive applications from every single continent, gaining a spectacular example of international collaboration, innovation and competition. The First prize - of €15,000 cash and an invitation to the WebSummit - was awarded to Safe Drive, a smart e-call service; the second prize of €6,000 was awarded to KarMa, a holistic car companion app; the Third prize of €3,000 was awarded to Virtuo, a mobile-only car rental solution.

As we can see from the examples, progressive car makers are no longer relying on simplistic market research or focus groups when testing the potential of new products, instead, they are sourcing for consumer feedback at the design stage to ensure that their products meet or exceed market expectation, while gaining a competitive edge over rivals. BMW, in 2010, launched the new platform *Co-Creation Lab*, a virtual community where consumers can offer their opinions on its designs, submit their own ideas, and get involved with the development of concept vehicles. The Co-Creation Lab is a virtual meeting place for individuals interested in car related topics created to implement co-creation innovative projects. People share their ideas and opinions on tomorrow's automotive world and collaborate with BMW experts. Customers are plugged into the design process from inception to potential completion, giving them a very real and vested interest in the finished product. The ideas contest for the customization of vehicle interiors offers young creative talents the opportunity to put their design skills to the test. The first open innovation project launched within the BMW Co-Creation Lab Contest was the "Tomorrow's Urban Mobility Services". The company was interested in ideas and collaboration about innovative mobility services in cities and metropolitan areas of the future, so they created five topics through which ideas could be submitted: Mobility, Parking, Electric cars, Networks and Communications and Applications. BMW USA, in 2012, also launched a YouTube contest called 'Zero to Desir3 in 5.9' — a reference to the time it takes the vehicle to go from 0 to 60 mph. The contest asked participants to submit a video running approximately 5.9 seconds, showing how much they “desire” a new BMW 3-Series Sedan. BMW has done several efforts in order to promote innovation and development of automotive industry by engaging customers and external partners.

3.4.3 Automotive Product Customization

In addition to the process of generating new ideas, the end users can also collaborate in the process of selecting ideas for the creation of new products and the creation of the goods themselves through special tools made available to them, increasingly taking advantage of online configuration tools. Personalization has always been strongly hindered - especially in Italy, as opposed to the U.S. – by a series of rules often difficult to interpret and sometimes in contrast with each other. The new European code, which has been implemented by the Italian state, recognizes the ability to customize your car without having to resort to the permission of the manufacturer, to the delight of all motorists eager to make their car unique. Most car manufacturers, in fact, give their consumers the possibility to customize the product within predefined possibilities. Some of these companies, however, have used 4.0 technologies to make this process even more excellent.

Volkswagen America was one that pushed customization one step ahead on common product configuration. Thanks to a collaboration with Mackevision, the Accenture leading company on computer animation and 3D visualization, VW introduced a car configurator inspired by dating platforms. Before this collaboration, VW customers could only configure their new car online basing their choices on which models their dealer had in stock. Volkswagen of America then launched a completely new configurator website that totally transforms the experience of buying a car, even at the early decision-making stage. At vw.com, in the Build your Own section, customers can enter their preferred parameters just as easily and precisely as they would on a dating platform, and what’s more, their configuration options are no longer limited by the stock of the customer’s VW dealer, but include stock from other dealers as needed. Customers have the possibility to see a virtual rendering of their fully configured “perfect car” on the website before they visit the dealer. The new buying experience was made possible by an innovative “matchmaking” solution developed in close cooperation between Mackevision and the Deutsch agency. For each vehicle there are 88 configurable representations, each one can be combined with 18 different backgrounds and a variety of interior and exterior views, making for more than ten million possible image combinations in all.

Alongside the usual car configurator, thanks to which the consumer can configure his model directly from its own home living room by choosing among the options provided by the manufacturer, Audi has brought the product personalization experience to a higher level thanks to the *Audi Exclusive program*: as is stated by the company itself, "Audi exclusive gives the customers the opportunity to turn something special into something truly personal". Audi exclusive offers broader options to product configuration and allows customers to become designer themselves through the collaboration with Audi exclusive studio, where they can present their creative ideas and personalized request. Audi Exclusive studio focuses on a great combination of extravagant colours and materials, making it possible to go far beyond the design options of the standard series; the personalization allows to made changes in both the interior and the exterior of the car, for example by customizing exterior mirror housing, decorative inlays, entry still trims and, depending on the model, further special individualization are possible, like embroidery of initials.

Ford is historically known as a mass production company. Starting from the production of the black, standardized Model T, Ford has made giant steps in product personalization, following the contemporary trends and market needs. Ford provides a Build and Price section in its website, where customers can configure their products by choosing among different interiors, configurations and exterior options. Furthermore, in 2015 Ford became the first auto manufacturer to launch a *Vehicle Personalisation Centre* in India, enabling new EcoSport buyers to customise their favourite urban SUV. The centre was designed to offer a superior quality, premium vehicle personalisation options to give Ford customers the 'power of choice' that further enhance the great value proposition of the Ford EcoSport. "Customers today view vehicles as an extension of their own personalities and are keen to customize their cars to stand out from the clutter" said John Cooper, vice president Customer Service Division at Ford Asia Pacific and Nigel Harris, president, Ford India. The centre is equipped with 19 ergonomically designed modification bays operated by Ford's trained technicians. The initial personalization offerings include Spare Wheel (Cover) Pack, rear-spoiler, LED scuff plate, and roof crossbar, everything offered at affordable prices in order to strengthen the value proposition of the car.

Fiat Chrysler Automobiles group together different brands and car manufacturers that are quite differentiated for value proposition offered and target market. However, in a way or another, product customization is a fundamental objective and purpose for most of them. The first one that deserves to be cited is *Abarth*, that was born with the specifically intent to produce sport versions and elaborations of FIAT cars. Abarth 595, the elaboration of Fiat 500, offers a multitude of different combinations, starting from the wide range of engine, ride and brake tune-up kits, that can be used to customise the car on all levels to secure a unique driving experience in terms of performance, handling and safety. Furthermore, a wide range of kits and accessories are available for all Abarth models for customisation enthusiasts. Five engine kits, three brake and suspension kits, style kits and an increasing number of special accessories confirm Abarth's vocation for modifications. The company's business model, focused on product customization and elaboration, proves to be a winning strategy especially in 2018, the year in which Abarth reached the absolute record for sales in Europe with almost 23,500 registrations and a 36.5% growth compared to 2017.

Inside FCA group, Maserati provides an even more personalized and unique customization experience thanks to its Centro Stile. The new *One of One* customization program is a way Maserati introduces to valorise Italian artisanal craftsmanship and offer the consumer a totally personalized experience. Customers can select from thousands of interior and exterior options to meet their personal needs and tastes, with the result that the final car become a unique piece completely connected with his owner. Maserati Centro Stile and its designers work closely with each client to create a vehicle, as unique as each person who drives it. This program exemplifies Maserati's ability to construct customized one-of-a-kind automobiles. One of the most striking examples of this program is the Levante GTS One of One for Ray Allen, the NBA Champion, released in world premiere at the New York International Motor Show 2019. The car, developed by the Maserati Centro Stile on the wishes of the basketball player, dresses a three-layer livery 'Blu Astro', inspired by the astral blue of the galaxy but also the colours of the city of Miami, particularly loved by Allen. As a hidden personal detail, Ray's signature is embroidered behind the headrest of the driver's seat while Finally, another exclusive element is inserted in the backlit door sills: a laser engraving that seals the dedication 'Maserati *for Ray'*. Another example is the Maserati Levante Allegra Antinori's ONE OF ONE, a unique project by Centro Stile Maserati, where Allegra Antinori, vice president of Italian wine producer Marchesi Antinori, had the chance to express herself in each detail of her new car, in a genuine process of shared creation, a concept which is much more than the mere choice of accessories. The external colour of the car is a distinctive tri-coat green, a special, unique colour inspired by the shades of the Tuscan hills. The interiors of Allegra Antinori's ONE OF ONE feature many unique combinations, which have never previously been used on a Levante. The lower dashboard, door panel, central tunnel unit and seat colour references the warm hues of the earth of Tuscan vineyards.

Maserati One of One program is an impressive example on how much important is becoming a personalization experience in the automotive industry, especially in the luxury segment.

As almost every car manufacturer, Mercedes Benz provide to its customers an online car configurator – Build your Own Car – where you can choose among different models, exterior and interior options, accessories, virtual assistant, entertainment and safety options and more. Mercedes made one step ahead in the customization, offering its customers a completely individualized experience thanks to the designo® Manufaktur Custom Order Program. The designo® options were already well known by Mercedes customers, since for over 20 years, they provided customers with a unique method to enhance their vehicle. The designo® Manufaktur took individualization to the next level, allowing the customer to order distinctive exterior paint colours and interior leather stitching colours that are outside of the normal product offering. The designo® Manufaktur program is a true made-to-order experience, offering individually tailored solutions to the customer's desires.

Bmw customizes the cars with various options to respond to the customer expectations. They collect customer data by the CRM system from two primary sources: service records and data recorded on BMW's "*KeyReader*" devices. Service records involve customer opinions, such as complaints or requests. Such information sometimes provides useful user feedback on product configuration. Furthermore, KeyReader device, introduced by BMW, autonomously keeps track of the timing of service visits, maintenance requirements, quality of the fuel consumed. Furthermore, the system can record data about the driving dynamics captured from the actions of the customer. For example, the system can calculate the count and the duration of brakes. The statistical data collected by KeyReader device are transmitted to a global database in the global HQ. The database is then analysed by the engineers when the parts of the car are designed. Besides, geographic data is also taken into consideration in the analysis, useful when customizing the product line across countries. Another important customization tool utilized by BMW is the "*ConnectedDrive*" technology. This technology is integrated into the car by a platform that enables a wider range of features. A timesaving feature helps the owner when a target location and time is shared with the car. For example, the navigation system remembers the address when the driver gets into the car as well as the owner's frequent routine destinations. When there is an accident or a traffic jam on the daily route, the owner is notified to help him saving time. Within the context of new Industrial Revolution, disruptive developments are expected for the personalization of BMWs. According to a BMW senior executive, Ozgorkey (Executive Committee Member, Ozgorkey) "In BMW's plans, Vison Next 100 – the BMW

Concept Car of the future - represents the future of BMW cars. The car is totally custom-tailored and equipped accordingly. Today, using the smart key technology, a customer can park his/her car (remotely); the smart key tells the customer where the car is parked. In 7-series and 6-series, the system works as this way. The next versions are powered by Apple's software; the voice control feature works seamlessly, for instance I might tell the software to order and deliver a 13-carat diamond for my wife. I will also be able to use the car as a well-equipped office. The car will help me to order from a grocery store, help me in hotel transfers and so on. Autonomous driving will get prevalent after 2020, the system will handle driving and you will have the opportunity to rest. It takes up to 4 months in total to make a completely custom-tailored car, transport from Germany and deliver to the owner." The design of Vison Next 100 introduces innovative technologies such as autonomous driving and augmented reality. The smart features above mentioned can be qualified as a high-level personalized car. According to what the executive said, BMW offers virtually unlimited individualization for custom orders. Furthermore, the customize application '*BMW Individual*' allows to explore various options for paint finishes, interior trim, and equipment. The customization options offer numerous colour and style options for interior and exterior of the car. Furthermore, textures used in wood and leather decorations can be customized. It is even possible to include owner's signature in the interior design of the car. Essentially, premium brands mostly offer such customization options in different ways for a long time. However, it can be argued that BMW individual vision respects BMW customers as a co-designer through the mobile applications powered by augmented reality technology. To summarize, it has been noticed that smart and innovative customization practices in BMW represent the characteristics of personalization theme; particularly those enabled through data analysis and customer-driven design (Kabasakal, et al, 2017).

3.5 Automotive Virtual Reality Experiences

Virtual Reality (VR), as well as Augmented Reality, has proven to offer automobile designers in almost all areas promising opportunities to make their business more efficient and cost-effective. The automotive sector is already making intensive use of these opportunities and it is considered to be the sector that has already made the most progress with the digitization of its processes. AR finds a variety of ways to be innovatively applied in the automotive industry: inside a vehicle (e.g., Holographic Augmented Reality Navigation System), outside a vehicle as a part of its maintenance (e.g., Volkswagen’s MARTA system for service technicians) and for the vehicle creation. According to Lawson (2016), the major applications of VA in the automotive industry are related to the Design process, Virtual prototyping, Virtual Manufacturing, Virtual Assembly and Training. Given these benefits provided by the implementation of VR to the automotive industry, several automotive firms are currently investing in the development and implementation of VR products. One example is Jaguar Land Rover (JLR), whose design and engineering headquarters in UK hosts the Virtual Innovation Centre (VIC), a world-leading centre for VR technologies for automotive applications.

Volkswagen group introduced the VR system *Marta*. Marta is an acronym for Mobile Augmented Reality Technical Assistance and is a new system by Volkswagen that will greatly help mechanics in the various vehicle assistance operations of the near future. Through a tablet with integrated camera, mechanics will be able to frame any area of the car and choose the intervention they are about to do. On the screen of the tablet, the application is able to draw on the screen the movements and passages to implement any type of maintenance on the car and also which tools to use for each operation. The operation, from the point of view of the end user, is very simple and intuitive: the application indicates where to position to do a certain intervention and, once the outline of the car is recognized, begins to explain all the operations to be performed step by step, so as not to run into possible errors, sending the workshop manuals, difficult to consult and bulky, into retirement.

Audi introduced for the first time the VR experience in 2015 in a beta version for test operation at selected dealers in Brazil and Germany. Feedback from customers and dealers has enriched the further development of the system. Audi is offering an innovative, digital, retail solution which allows customers to customise the Audi of their choice. With the VR technology, customers can get an extremely realistic experience of their individually configured car, down to the last detail. The VR experience explains Audi technologies intuitively and offers customers the opportunity to immerse themselves virtually in extraordinary moments from the world of the four rings. As part of Audi’s comprehensive initiative for digital innovation at dealerships, the VR experience is completely integrated into the brand’s IT systems. “With the VR experience we have developed a full-fledged sales tool for Audi dealers. It offers our customers more information and certainty when making their purchasing decision, as well as a special excitement factor,” says Nils Wally, Head of Digital Business Strategy/Customer Experience at AUDI AG. “With this, we are taking the next step in our strategy to combine digital innovation with the strengths of the bricks-and-mortar dealership.”

Furthermore, Audi presented at CES 2019 its new *Holoride* technology. The carmaker has co-founded a start-up named Holoride which is commercializing a platform that will integrate the car's movement into VR contents, letting backseat passengers view video, play games and live experiences using a VR headset. The platform is slated to be open, and available to all carmakers and content developers in the future. The German brand believes Holoride will be available to vehicle owners within the next three years.

Virtual realities provide unique ability to allow researchers with an immersive engagement with a project. In 2015, Ford introduces its *Ford's immersive Vehicle Environment* (FiVE) Lab. The FiVE, which is led by Elizabeth Baron, Ford Virtual Reality and Advanced Visualization technical specialist, allows the company to virtually test in ultra-high definition thousands of product design details under simulated conditions. Another benefit of the Lab is that he offers the opportunity for collaboration between Ford's global team of designers and engineers on products in real-time for the purpose of improving products and the experience for consumers. In fact, FIVE fosters an amazing level of collaboration, by letting people on different continents being immersed in the same model at the same time. What is important is that this system allows collaboration even for people that are coming from different backgrounds and disciplines talk, understand exactly what's going on, and determine the vehicle health from many different disciplines: it allows design to converge with engineer.

The FCA Group invested on Virtual Reality up on many sides. In 2016 elaborated a prototype of an Immersive Augmented Reality Car Configurator developed in collaboration with Accenture and Google's Project Tango, that allows to understand how VR can revolutionize the shopping experience for consumers by allowing them to view and interact with a full-scale virtual version of the object. FCA also introduces the *Immersive Virtual Reality* (iVR) laboratory, the home of an Immersive Virtual Reality system, which is composed of eight infrared ceiling-mounted cameras, two Head-Mounted Displays (HMD) and three workstations. The lab enables the user to interact with the virtual environment. Moreover, the FCA the Virtual Reality Trainer allows the employees to simulate and experience different possible scenarios, and the dangers that are present, watching and feeling what happens in those scenarios, according to his own behaviour and safety measures followed. The implementation of virtual reality solutions inside the FCA factories have brought several benefits.

In 2018 Mercedes introduced the new '*Ask Mercedes'* intelligent virtual assistant. It is an application that substitutes the old paper manual and allows to scan with the phone's camera the interior of your Benz and place numbered AR beacons on specific parts throughout the interior. Clicking on any of these informative indicators will access information on specific components in the form of how-to videos, or through a digital version of the owner's manual. This increase the functionality of the car and improve the owners' experience. There are also non-driving benefits of Mercedes switching to an AR manual, for example the fact that in this way the company drastically reduces the amount of paper it would normally use to print a traditional car manual – in 2017 the company sold approximately 2.5 million cars worldwide, just to have an idea of the paper saved. Furthermore, Mercedes introduced a Virtual Reality Experience for its C-class, that allows customers to see all of the features of the C-Class coupe in 360° easily on their phone.

BMW uses VR technology in these three areas:

- *Workplace planning*: With VR, BMW plans buildings and systems completely virtually, so that everything fits to the millimeter and looks exactly as the employees need it. In a virtual library, BMW collects shelves, mesh boxes, small load carriers and around 50 other particularly common resources.
- *Training and qualification*: In its own production academy, BMW trains managers, production planners, production specialists and quality specialists following the principles of lean production. VR glasses have been used for a year and a half to simulate and train engine assembly. Visualizations guide through all work steps and provide specific information. The speed of the training is determined by the participants themselves via voice control. The scenarios can easily be adapted to other areas without incurring in further development costs.
- *Comparison of component and design data*: When new parts and tools, sometimes weighing tons, are developed, everything has to fit perfectly inside the car. At BMW, AR technology is used for comparing tools with the CAD data, in order to understand if there are any mistakes or defects or if the plan and the component match. In the course 2019, the toolmaking department at the Munich site will completely convert the incoming inspection of delivered tools to the AR application. The tedious comparison between CAD data on the screen and the tool is then a thing of the past.

Bmw also introduced AR application for customers' experience, for example the BMW *iVisualizer,* an app that allows customers to create their own personal BMW i3 or i8 simply by moving their fingers on the phone. Customers can select the exterior and interior, virtually open the car's door or even switch on the light.

Virtual Reality has proven to be a very precious tool that is able to facilitates internal work in the manufacturing plant, to enable communication among experts in a long distance, but also to enhance customers experience and involvement.

3.5.1 Automotive Industry and 3D Printing

According to Deloitte University experts (2014) additive manufacturing technologies, commonly known as 3D printing, "have transformed the potential ways in which products are designed, developed, manufactured, and distributed". For the past few decades, 3D printing in the automotive industry was primarily used by carmakers to create automotive prototypes to check their form and fit. The first technology allowed for weaker parts, that could not be used for long periods. Today, advanced in technology and in materials utilized, allows for further applications for carmakers – not only for prototyping but also for production. The core applications are Design and Concepts for communication, Prototyping validation, Preproduction sampling and tooling, Customized parts, Replacement parts for rare or vintage vehicles, Standard Components. In the future, 3D printing technologies will lead to the development of specialized micro-factories for the production of custom parts, while the automotive industry will move away from general mass production and towards mass customization. According to the market study "Global 3D Printing Materials Market in Automotive Transportation, Forecast to 2024" by Frost & Sullivan, the market for 3D printing materials in the automotive industry is expected to grow at double-digit annual rates to up to 576.5 million euros by 2024. This corresponds to an impressive average annual growth rate of 17.8 percent (2017 to 2024).

In the automotive sector, 3D printing constitutes a series of advantages with a great potential, first among them the possibility to print pieces with complex shapes quickly and rather efficiently. Another thing that makes it practically unique is the possibility of being able to carry out design changes, both in the course of work, and in the postproduction of a particular component. The word *customization* is the one that best embodies the importance of 3D printing within the automotive sector. Being able to make changes and variations to a specific component of a car remains a very important element that does not force the car company to completely review the molding machines, thus allowing for a greater efficiency and reduction in costs and production time. According to Sculpteo (2018), a 3D printing online manufacturing service, the main benefits of 3D printing car parts are reduction in weight, with a possible reduction of more than 70% of the weight, that allows for reduction in fuel costs and more environmentally and cost friendly parts; reduction in material loss, since 3D printing only uses the amount of material that is needed without leaving excess material that goes to waste; creation of customized car parts for those car enthusiasts that wish to create a unique car with unique additional design features, in fact 3Dprinting gives the companies the possibility to offer customization options for literally every single customer, from bumper, rear mirror to some other, more exquisite parts as well; easy replacement of spare parts, especially when those parts are out of production from the mother house since they belong to very old car models and finally Savings in costs with a great ROI. It is important to underline that 3D printing in Automotive industry is not only manufacturing itself, made up of the design and production of cars and components. As shown by Sculpteo, the penetration capacity of the 3D printer in the automotive industry can also affect the world of spare parts and the aftermarket. The use of 3D printers has already begun to take hold in the vintage car market. In this case, with the help of a 3D scanner, it is possible to reconstruct parts of the bodywork that otherwise could not be found because they are out of production. The automotive aftermarket was 286.2 billion euros in 2013 and is projected to hit 378.3 billion euros in 2020 according to Autocare.org. This represents a lot of cost in shipping, packaging and logistics. In addition, original equipment suppliers (OES) have an obligation to produce and ship parts for its vehicles for 15 years. This represents a lot of cost in shipping and inventory. 3D printing can occur in this scenario by lower those costs and secure more efficiency both for automakers and for private aftermarket parts dealerships. Thanks to the 3D technology it is possible to obtain the desired piece, in plastic or aluminium, starting from a file with the design data provided by the parent company. A true revolution, which in a close future can become widespread in all garages or in spare parts stores: at this point it will be enough that these workshops have a large 3D printer to be able to produce "just in time" the desired piece, even if it belongs to a car that is now out of production. A real savings, because transport, shipping and logistics costs will be completely cut. Spare parts market will securely grow, fuelled by delivery capabilities, price drops and availability. Some of the most advanced car manufacturers, like Porsche, already adopted this strategy. The company, for example, has decided to create eight spare parts, some even in steel, via 3D printers for its Classic sector dedicated to historical models that have been built for years no longer, that way satisfying those owners of vintage cars that are no longer forced to real adventures to procure spare parts that have been out of production for years.

Figure 38. Strati, the World's first 3D Printed Car

Source: Local Motors, 2014

Among the companies that currently use 3D printing technology in a profitable way we can include *Local Motors*, an Arizona company that has decided to adopt 3D printing technology as a tool to exploit low-profit profitability, vehicle customization, use of recyclable materials and rapid vehicle development. Local Motors, since its inception in 2007, has used 3D printing as well as a marketing vector and to make itself known, also as an element of sustainability. In 2014 Local Motors, Cincinnati Incorporated's BAAM Machine and Oak Ridge National Laboratory, in collaboration with the U.S. Department of Energy's (DOE), presented the world's first 3D-printed car at the annual International Manufacturing Technology Show (IMTS) of Chicago: The Strati (**Figure 38**.). The vehicle has been 3D printed in one piece composed by 212 layers of carbon-reinforced ABS plastic, using direct digital manufacturing over 44h, then rapidly assembled by the Local Motors team. Only mechanical components, like battery, electric motor, wiring, and suspension are sourced from Renault's electric Twizy car. As Haye – a general manager at Local Motors said "Despite the looks, with a stepped approach to curves giving the Strati a resemblance to a giant Lego car, 3D-printed cars can be as safe or safer than current vehicles, with 3D printing able to take advantage of complex geometries and lightweight structures. 3D printing is also beneficial for the environment," adds Haye, "as it allows for the reuse of the vehicle body if a customer requests a change or the vehicle simply reaches the end of its lifespan. The body can be broken down and reprinted into a new vehicle or even a different product. Finally, 3D printing allows for customisation based on a customer's wants or the needs of a specific geographic region." Today, the company is known for its USP (Unique Selling Proposition) of co-creation of automobiles. The ideas are submitted online and the most voted idea for the car design goes into production stage. Local Motors aims to target only a niche market and produce and sell just 2000 units before retiring that model. Being an

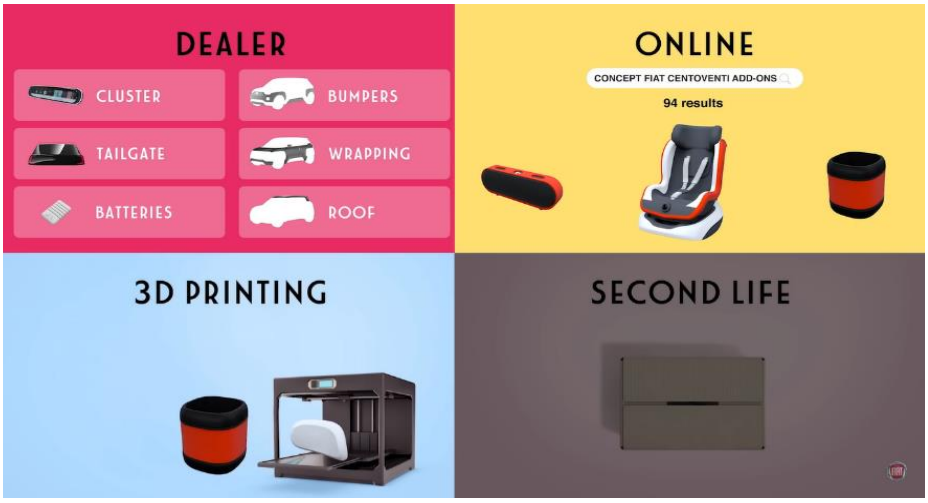
open source vehicle company, Local Motors openly shares chassis and body data. Hence, it can be easily downloaded, and parts can be easily modified as per one's preference.
At the same time several manufacturers - including Ferrari, Lamborghini, Volkswagen, Ford, Audi and Bmw, just to name a few - are testing the potential of 3Dmanufacturing applied in the automotive industry. Those companies are now focused on the creation of individual metal parts. The intent is to be able to contain the manufacturing costs of the various components - chassis, engine elements, car interiors - so as to start large-scale production. A goal that is certainly not simple and on which car manufacturers have decided to allocate part of their resources: through the creation of ad hoc divisions within their companies and partnerships with printer manufacturers.

Volkswagen is focusing on enhancing operations with 3D printing. The company utilizes desktop 3D printers for creating tooling, jigs and fixtures, and larger machines are now bringing metal 3D printing into end-use part production. The company has announced work on metal components with technologies from HP for mass production and Additive Industries for advanced tooling and spare parts. After having validated the concept in 2014, Volkswagen Autoeuropa in 2018 had 7 Ultimaker 3D printers in operation and produces 93% of all externally manufactured tools in-house. The transition to 3D printing saved Volkswagen Autoeuropa 91% in tool development costs and reduced development time by 95%. 100% return on investment (ROI) was accomplished within two months of implementing 3D printing. The entire VW Group owns more than 120 plants worldwide for additive production with metal and plastic. The group goal is to build a worldwide 3D printing network for the Volkswagen concern that will supply employees in all locations with printed innovations.

In the heart of the Audi R8 factory in the Böllinger Höfe, there's a futuristic hotspot: the 3D Printing Center in the start-up/analysis centre. Audi is expanding the use of 3D printers in Production. Custom designed and locally printed, auxiliary tools from the 3D printer help employees on the production lines. "By establishing a separate specialist department for 3D printing, we are professionalizing this already successful project. Even more employees will be able to benefit from the experienced expert team and the custom auxiliary tools in the future," said Helmut Stettner, the Neckarsulm plant manager. But Audi is also using the project to actively drive cultural change. The employees on the production line are directly involved in the development process for the 3D-printed tools. The company gives top priority to focusing on the employees and their needs. "When designing a prototype, it is very important to us that we fulfil our colleagues' wishes exactly," he said. "Our goal is to provide our Audi colleagues the 3D-printed tool as quickly as possible, thus supporting them in their daily work."

Ford introduced its first 3D printer in 1988, and today it counts 90 installed 3D printers in use in global operations. Applications range from spare parts for its own production lines to 3D printed brake parts for the 2019 Shelby Mustang GT500. In December 2018, Ford announced a $45 million investment into its Advanced Manufacturing Centre housing 23 3D printers. Ford team is well aware of the time- and cost-savings possible by integrating 3D printing into its manufacturing workflow. Ford put a particular emphasis on the importance of people, especially enhancing the inside development of advanced manufacturing technology experts and a skilled workforce, also establishing a solid relationship with 10 3D manufacturing companies. Ford experts during the last years developed applications with different materials – from sand to nylon powder to carbon that have the potential to save the company more than $2 million. Ford developed 3D printed parts in the manufacturing and production of vehicles, but it also exploits 3D manufacturing to help employees improve vehicle quality, reducing development time – like in the case of the Ranger pickup- and ensuring the best standard qualities. In Ford workers collaborate with advanced manufacturing experts in order to identify ways to save the company time and money, including how to 3D print replacement parts to keep lines running instead of waiting for parts that can take weeks to be fabricated.

Figure 39. Concept Centoventi Accessory Line



Source: FCA, 2019

FCA introduced Additive Manufacturing technology in the Prototype department at his Product Development Center of excellence in Turin, where they – for example - created the grille for the Alfa Romeo Giulia – a project developed in collaboration with the FCA Style Center. FCA utilizes 3D printers to obtain exceptional results in terms of time, precision and environmental impacts. The flexibility and speed of this technology also allows that inventory space can be reduced. Another example of FCA 3D printing development is the new prototype Fiat Concept Centoventi. The Fiat Concept Centoventi is a non-production electric concept car presented at the 2019 Geneva Motor Show. The main theme of the Fiat Concept Centoventi seems to be customization and configuration of almost everything, starting from the interior, colours and exterior and finishing onto the battery pack size. Fiat Concept Centoventi can be constructed just as the owner wishes. Except for six features (bumpers, polycarbonate roof, livery, Lingotto instrument cluster, batteries and digital tailgate), which can only be installed at dealerships, the other 114 accessories are specially designed by Mopar - the FCA group division that specialises in accessories, parts and services and enables innovative product personalisation. What's more, some simply structured accessories, such as a cup-holder or a document-holder are thought to be printed using a 3D printer, in the owner's home, at their dealership or at a specialist printing shop, just downloading an online file (**Figure 39**.). This represents an entirely new business model for auto accessories, enabling them to be resold or traded on the Web and creating a real community of brand fans or connoisseurs of Fiat’s Italian design. Even if it is just a Concept, it shows how automotive companies like FCA are projected to 3D printing as a powerful tool at everyone’s disposal that can change the way people related to the automotive accessory world. This new business model leverages on the virtual market which knows no boundaries.

Mercedes was one of the first car maker companies to use 3D printing in its production cycle. The car manufacturer introduced its first 3D printed piece in 2017: a thermostat cover for Mercedes trucks and Unimog models, that had been no longer in production for 15 years. At the moment, in fact, the most widespread application area for 3D printing for Mercedes is spare parts, particularly with regard to historic parts: various spare parts are coming to market for some Mercedes models of the era. All printed spare parts meet the high-quality criteria of the Mercedes brand and correspond to the original part in all its properties. Digital production technology helps maintain the classic brand standards according to traditional specifications. Mercedes molded metal components have excellent resistance to workloads and heat. They are distinguished by an even density and a higher purity than conventional injection-molded aluminium components. The 3D printing process in Mercedes also reduces development costs and the use of special equipment. Significant advantages are also found in terms of logistics and waiting times for spare parts by customers. This gives Mercedes-Benz customers spare parts available quickly and at affordable prices, even years after the production of a model has ceased.

In 2018 BMW alone 3D printed more than 200,000 components, a 42 percent increase over 2017, that is showing an upward trend. In the same year, the company reported that it had 3-D printed its one millionth component in series production since 2010, having been working with additive manufacturing since 1990 for prototyping and development use. That millionth part, a window guide rail for the BMW i8 Roadster, was created using HP's Multi Jet Fusion technology; up to 100 of these parts can be produced in 24 hours. Thanks to the work of specialists at the Additive Manufacturing Center, the i8 rail took just five days to being developed and was integrated into series production shortly after. The window guide rail is the second 3D-printed component in the BMW i8 Roadster. The first was the fixture for the soft-top attachment, which is also produced at the Additive Manufacturing Center in Munich. Made of aluminium alloy, the metal component weighs less than the injection-moulded plastic part that is normally used but is still considerably stiffer. The BMW Group is constantly exploring ways of using additive manufacturing to the customer's advantage. Another important example of 3D printing car parts by BMW is the one introduced by Mini for mass customization. BMW understood the importance for some categories of customers to be allowed for a personalization of vehicles and components. With the *MINI Yours Customised* product initiative, customers can design selected components themselves, such as indicator inlays and dashboard trim strips and LED puddle light images. They create their designs at the online shop (www.yours-customised.mini), and the parts are then 3D-printed to specification.

Once the customer orders their custom design, Mini says it will 3D-print the piece and deliver it within a few weeks. The customer can then install the piece themselves or have a dealer do it. Mini also thought about the problem related to the resale value that will suffer a drop after the car being customized. To prevent that from being an issue, Mini allows the owner to swapped out the custom part and put back the original piece before reselling the car. That also means it will be possible to switch back and forth between different designs the customer may like. MINI Yours Customised was honoured with a special price: the gold German Innovation Award presented by a foundation called the German Design Council. It represents the first step toward more in-depth customization options in the future.

Table 7. Summary of the main car manufacturers Innovation 4.0 initiatives

		VOLKSWAGEN	AUDI	FORD	FCA	MERCEDES-BENZ	BMW
CO-CREATION		**People's Car Project** China's long-term co-creation interactive platform	**Virtual Lab 1 & Virtual Lab 2** Infotainment system and new product development co-creation	**Your Idea platform on the fordstory.com & Joint technology framework** To provide special access to suppliers on intellectual property for co-developing commercial products	**Fiat Mio** Crowdsourced car of the future **&** **Fiat 500 days** Co-design accessories for the car with customers	**First Thoughts in Singapore** Crowdsourced innovative solutions **&** **MB Digital Challenge** Crowdsourced APIS for a connected car	**Co-creation lab** Virtual co-creation on community ("Tomorrow's urban mobility services" was the 1st contest)
PRODUCT CUSTOMIZATION	**CAR CONFIGURATOR**	**Built Your Own section**	**Audi Car Configurator**	**Build and Price section**	**Abarth & Brands Car Configurator**	**Build Your Own Car**	**BMW Configurator**
	ONE-TO-ONE CUSTOMIZATION	✗	Audi Exclusive Program	Vehicle Personalization Centre in India	**Maserati One-to-One** in Maserati Centro Stile	**Designo Manufaktur** Custom order program	**BMW Individual Connected Drive Technology**
VIRTUAL REALITY	**VR SYSTEM**	**MARTA** Mobile Augmented Reality Technical Assistance for mechanics	**VR experience** At selected dealers **VR HOLORIDE** For passengers	**FIVE LAB** Ford's immersive vehicle environment for product design test – real time global designers and engineer's collaboration	**Immersive virtual reality lab iVR** For employees **Immersive augmented reality car configurator**	**Ask Mercedes** Virtual assistant manual **C – class VR experience** For customers	**VR technology** In workplace planning, training and product development **BMW iVisualizer** For customers
	HEAD-UP DISPLAY	✓	✓	✓	✓	✓	✓
3D PRINTING		**Volkswagen Autoeurop** Plastic and metal components	**3D printing centre** Prototyping and auxiliary tools for employees	**Advanced Manufacturing Centre** 90 globally installed 3D printers Spare parts with different materials tools for employees	**Prototype Department** In Turin, for spare parts like grille for Alfa Romeo Giulia **Fiat concept 120** Customization from 3D files printed at home, at dealership or at printing shop	**3D printed** **Old spare parts,** like for older Mercedes trucks and Unimog models	**Additive Manufacturing Center** From 2010 printed 1 million parts **MINI Yours Customized** For end-user's 3D printed customization

Source: Elaboration from company websites, 2019

4 Explorative Analysis

This analysis focus on a more in-depth view of the current status and impact of additive manufacturing and other 4.0 technologies connected to product customization in the automotive sector.

The methodology used in this research was to implement double-side interviews in order to identify the main trends within the industry and within customers' community. The final purpose is to depict a scenario that analyses the actual developments both in the offer and in the demand side.

The research is divided into two main parts, that are respectively focused on the demand and offer analysis of the phenomena. In the first part of this analysis there are three Case Studies that are introducing the interviewed car manufacturing companies trying to give a better understanding on what is going on inside their businesses and what are their main goals and characteristics connected to Industry 4.0 and Product Customization. The second part of the explorative analysis is focusing on the Automotive Makers Community, or better on those community of makers that are concentrated on producing, elaborating, ideating tools related to the automotive sectors. The community research consists in a multiple-choice questionnaire that was divulgated through communities of Makers constituted in the form of online communities like Forums, Facebook Communities and Blogs.

4.1 Case studies

The first part of the analysis consists of the case studies of three automotive companies that are adopting Industry 4.0 techniques in order to enhance product customization both in their product development phase and in the production phase. To carry out the case study investigation, an open questions survey has been made, that has been sometimes combined with information provided by secondary sources. The interviews were made in different modalities and types, depending on the needs and on the availability of the different companies. Two version questionnaires have been developed, one extended version, and a reduced version for those companies that asked for one. All the questionnaires are available (**Appendix A, B, C**). The intent of the research was to obtain diverse points of view about the theme from actors operating with different target markets and different types of final and potential customers. After the initial contact with the public relation offices, the interviewed have been made to the responsible specialists working in the R&D departments or the management of the company. Some interviews have been made by email, some other by call-conferences or by telephone. When it was possible, a more direct contact with the interviewed person has been searched for in order to facilitate the information sharing process and at the same time to better understand the philosophy and the attitude of the company. The three companies that will be presented are Bermat, an Italian start-up that patented a particular chassis that allows for a very broad car customization; Rimac, a young Croatian company rewarded for developing the fastest electric car; Xev, an Italian-Chinese start-up that developed an electric sharing car almost completely 3D printed. The choice of these companies stems from the fact that we want to show how Product Customization, combined with Additive Manufacturing and other innovative solutions in optics 4.0, can be configured in companies belonging to completely different positioning and that are offering products to end consumers that show different characteristics and needs.

4.2 Bermat - Company introduction

The first Case Study introduces an innovative Italian Start-up called Bermat. Bermat is a Trentino start-up founded in 2015 in the Rovereto mechatronics center. The company mission is to “build exciting cars for those who want to express their passion, allowing them to create their sports car with unique technical and aesthetic configurations”. With its innovative technological platform, the car company promises to put everyone in a position to create a "tailor-made" car, just like a suit, and to make this experience as consumer friendly as “playing a video game”. The reason why I found interesting to present this case is because it is a witness to the importance of offering a customizable product in the sports car market. Bermat is introducing a very interesting and innovative business model, completely based on the importance not only of customization of the end products, but on the personalization of the end customers’ shopping experience, starting from the very initial phases of the car order process. The customized shopping experience, connected with the possibility to shape the car’s characteristics based on their personal needs and desires, offer to consumers a great level of value created and it is the key on which Bermat is basing its entire business model.

4.2.1 Bermat – The History

Bermat was founded by two 41-year-olds: a former motor racing lawyer, Matteo Bertezzolo, and an aerospace engineer, Jacopo Franchin, expert in structural calculations and innovative materials. But how did this revolutionary company come about? Matteo tells of himself that he has always been passionate about engines. After being a freelance lawyer for 5 years, then a corporate lawyer for 7, when his company closed for reasons related to the crisis, he decided to introduce a radical change in his life that led him to launch himself headlong in a project as large and ambitious as that of founding a customized car company.

His idea was to create cars that could adapt to the needs and desires of the consumer, allowing the latter changes and customizations that Matteo himself had always looked for in his cars. His passion for automobiles, in fact, dates back to when he was a child: he was an automotive passionate since the age of five. When he was just a young kid, he used to "play" with the vintage cars of his friend's grandfather, dismantling the pieces and replacing them, sometimes doing great damage and catching the big rage of the grandfather on the machines. doing great damage and catching the big rage of the grandfather for his machines. The passion for the car grew with him, between practice and specialized magazines, until, as a novice driver, he bought a yellow Fiat 500, restructured it and sped through the streets of Villafranca, his city. Thus, in 2013, Matteo had for the first time in many years the opportunity to devote himself to his passion by pursuing the idea that anyone can build his custom car. He not only realizes that his idea had great potential, but above all that until then the market had never offered anything like that. In fact, what has existed for many years, is the possibility of customizing the car in an atelier, buying a production car and then dismantle it and customize it with a new body and the desired interior: the end result is of the highest quality but inextricably linked to the starting car chassis. This is what companies targeting the luxury market already do. This artisanal process, however, has important diseconomies and has very important costs and limits. Indeed, their range of action is limited by the DNA of the original machine and it is in any case a very expensive procedure.

Next to those companies there are also others such as TVR, Ariel Motor Company, Lotus and Radical Sportscars, which are aimed at the premium market, but which are more focused on the mechanical elaboration of the car.

Figure 40. Bermat Chassis Prototype

Source: Bermat, 2019

Bermat aims to place itself in the middle of these two markets, creating a customized car manufacturing process that starts from the chassis and ends with the bodywork. Their chassis allows to give a linearity of design, of process and therefore to be placed in the middle of these two ways of making cars. The car is seen not only as a means of transport, but as an emotional object, a projection of one's own style. Customization is a workhorse for car manufacturers, but due to the logic of the production on assembly line, customizing forces to pull a product out of the assembly line that should instead be mass-produced in large numbers, thus creating important diseconomies both in terms of time and costs to the production process. As a result, most customizations, except for a few exceptions of luxury cars like the ones analyzed in the previous chapter, are limited to the color, the rim, the leather inserts and other customizations easily reproducible in series. This is why Matteo concentrated his efforts on creating a malleable, modular frame. He designed through some sketches a chassis that he then showed to his friends, engineers, that were working for big car brands, showing them the drawings. They said it was very expensive, but it could be done. So, he patented it and then he passed to the phase of CAD engineering and structural calculations made by professional engineers. Subsequently Bertezzolo presented its patent to Industrio, an accelerator of start-up projects in Rovereto, which funded its project. The patent consists of a technological platform, with a software and a hardware: the first is the "car-creator", which is in charge of configuring the car, while the hardware is the actual chassis conceived according to the principles of modularity and interchangeability. The patented marching frame prototype is called MR-Chassis - programmed for both electric and hybrid: today it is motorized with a 4-cylinder boxer in a central rear position, but it can alternatively host electric engines and endothermic engines with 6 cylinders V and 4 in-line cylinders (**Figure 40**.).

4.2.2 Bermat – The Target Market

The target consumer identified by Bermat is a "car enthusiast, who sees in the car not only a means of transportation but an emotional object, such as a tailored suit, an accessory", a person - who can be both a man or a woman - that "loves the challenge, loves to put himself to the test" and that, thanks to Bermat, has the opportunity to express his "*pistaiolo*" soul. The initial objective is to give life to machines aimed at the essence of fun and emotion, starting from the design to the final use on the road. The end customer is identified as a middle-high class person, with a good income, who can afford a second or third car for sheer excitement and fun. The company excludes, at least at an early stage, a very high-end target consumer, which identifies car manufacturers like Ferrari, Lamborghini and Bugatti as their reference market, which do not rank among Bermat's competitors because they are part of a luxury market. For what concerns the target markets, Bermat has already registered its patent internationally within the target countries. The first market will be Europe, not purely and exclusively the Italian one. Among the strategic markets, in fact, Italy does not figure, because, as Matteo said, is a market that alone is not able to provide a sustainable turnover to the company. Europe is followed by emerging countries, and in particular Asian countries, which give a huge importance to the prestige of Made in Italy, and at the same time that value customization as an extremely important aspect even in the case of a car. Finally, with the time and the procedures required, Bermat will also attempt to land in the United States. Bermat’s car is going to position itself in a price range that fluctuates, for the basic model, from 70-80 thousand euros that are typical of premium cars, up to over 200-250 thousand euros - or even to touch the million - depending on the level of customization that the customer wants to reach and the range of materials and technologies used for the realization of the customized machine. The positioning of the basic model will be placed in the market segment of those Anglo-Saxon manufacturers that the company identifies as competitors, including Lotus, TVR and the other manufacturers above mentioned. Among the sources of competitive advantage of the company, Matteo identifies the possibility of 360-degree customization thanks to the implementation of the chassis, which allows the creation of a linear and economic custom car manufacturing process compared to what is used today for the vast majority of cases and which has a positive impact on the final price and on consumer satisfaction.

4.2.3 Bermat – The Product

Bermat offers its consumers an aesthetically appealing machine, fun to use on the track, a beautiful car that they can enjoy while driving. A machine that gives emotion because it allows the consumer to become its own “creator”. A car that, at the same time, wants to challenge the laws of the market by offering a product that maintains a good quality-price ratio, and makes reduced production and delivery times a further strength.

Bermat project required an initial funding of 150 thousand euros to which were added, through a crowdfunding campaign that lasted until January 2018 on the Milan platform Mamacrowd, another 100 thousand euros. The crowdfunding campaign has aroused much interest in the public and brought together a significant number of investors, including Trentino Sviluppo, which has invested a 5 percent stake in the total amount raised.

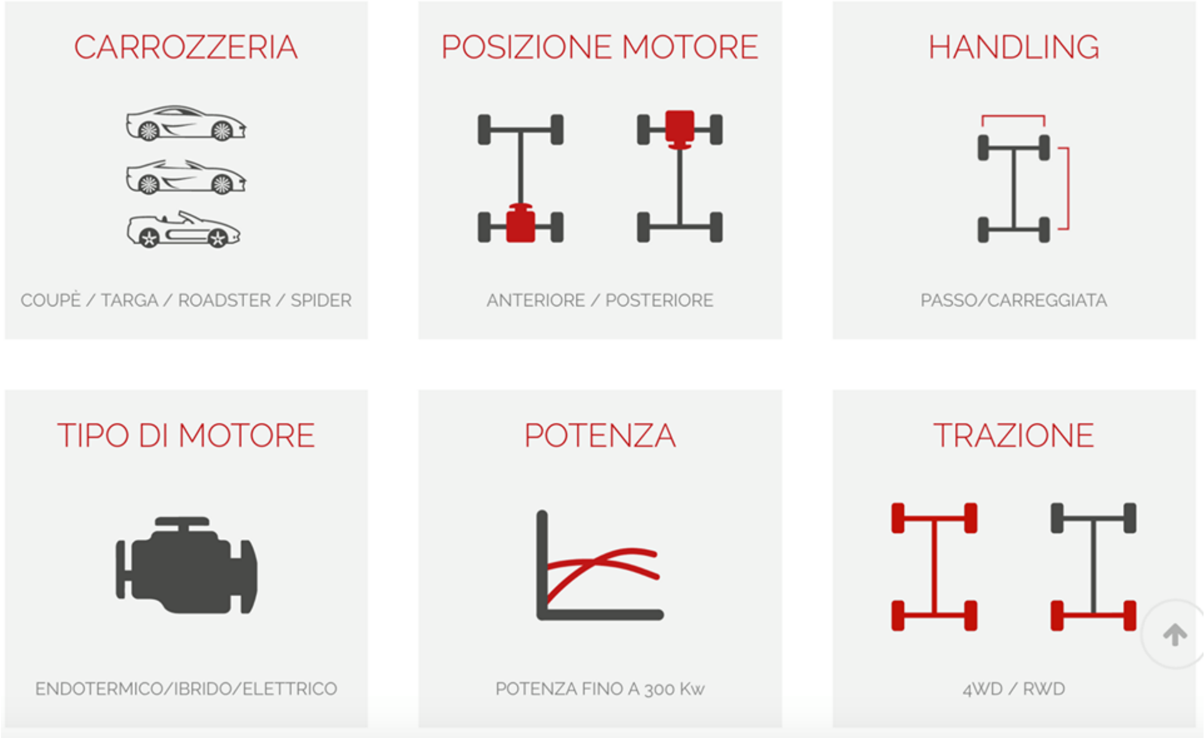
On 12 April 2016, Bermat won the Car Innovation 2016 competition, promoted by Euro Engineering, of the Adecco Group, and Digital Magics. The initiative's partners and members of the jury include: CRF of the Fiat Chrysler Automobiles Group (FCA), Magneti Marelli, IBM, Innogest SGR and Sapienza University of Rome. On 22 March 2017, Bermat was selected among the 110 start-up contestants to participate in the MCE 4x4 event organized by Confindustria Milan and Assolombarda. The aim of the competition was to reward the 16 start-ups that better represent innovative projects for the future of transport and the automotive world. The selection took place in two phases, the first characterized by the evaluation of a technical committee and the second by a vote on social media like Facebook. Bermat received the positive opinion of the committee and was ranked second in the social media vote. During 2017, Bermat was then selected by Maserati among the 16 finalists of the Maserati Live Innovation event. In the same year, Bermat was invited to Singapore for the summit organized by NAMIC on additive manufacturing (rapid prototyping technology that will be used by Bermat to further increase the level of customization of the MR-Chassis).

The company is now in the full phase of design and prototyping. A phase, according to Matteo, very delicate and complicated because “we must always stay within the budget that is modest and focus all our efforts on the success of the project to finally reach the market and future revenues”. 2020 will be the year in which Bermat plans to start with the sale of the finished product and, at the same time, to expand the corporate fabric and start recovering investments made.

4.2.4 Bermat – Product Customization

“Today more and more people want to stand out from the crowd and have a car that brings out their personality, they are no longer satisfied with what the market offers. In 2015, I founded Bermat to meet these needs, found a product that overcomes the limits that today the car manufacturers have in responding to the needs of this type of customization ". This way Matteo Bertezzolo introduces his innovative start-up. As already stated in the previous paragraph, through Bermat digital platform it is possible to create and buy your own car starting from an innovative patented chassis. It is not just a matter of customizing the options, but of "building" the car starting from the chassis, choosing between the rear-wheel or full-wheel drive, the front or rear position of the engine, in addition to the type of electric, traditional petrol or hybrid. And still the wheelbase and the roadway, but also the type of gearbox, brakes, wheels and suspension and moreover. The operation of the platform is so simple and compelling that it reminds the customization of the cars of certain racing videogames: Bermat will start from the realization of sports cars, which will progressively expand to the sedan and city car segments. Some current limitations - those who want the four-wheel drive can now choose only an electric or hybrid engine, while the choice between sports or manual gearboxes depends on the characteristics of the selected engine - they will be overcome with the evolution of the platform and subsequent close partnerships with the companies that supply the components. “In practice, the customer, choosing a type of frame from his own PC or smartphone, can decide for a rear-wheel drive or integral, the type of gearbox, brakes, wheels and suspensions, leather interior or sunroof: this is make your car tailor-made, just like in video games "explains the CEO of Bermat. The following Image gives an insight of what are the main customizable characteristics of the car and what are the options given to the customers. As we will see later, even more personalization is still and will be available.

Figure 41. Bermat personalization choices for the customers



Source: Bermat, 2019

As already introduced, the patent filed by Bertezzolo and Franchin, creators of the Bermat concept, essentially consists of a technological platform, with a software and a hardware: the first is the "car-creator", which is in charge of configuring the car, while the hardware constitutes the actual frame, conceived according to the principles of modularity and interchangeability.

Therefore, the company allows customization in terms of performance, design and finishes through its two integrated systems:

- The Car Configurator;
- The modular and adjustable MR-Chassis.

The **Car Configurator** (**Figure 42**.) represents the software patented by the company, which allows customers to choose online - directly from the website - the characteristics of the car: the type of engine, the power, the bodywork. It is also equipped with a 3D real-time display system. The Bermat configurator is a tool that is more evolved than what other car companies usually utilizes, inspired by videogames, in which the customer can make a selective path being guided by a sort of engineer or virtual stylist. The customization is not in the absolute hands of the customer: based on his choices, the configurator will operate exclusions in a path that will basically be a guided choice path. In fact, the configurator already contains "the knowledge of the engineers", the possible choices have already been engineered and all the data needed for configuration, such as weight, performance and so on, are already available in the database of the Car Configurator. For this reason, the level of preparation that is expected by the consumer is neither an engineer nor a professional pilot, but rather an enthusiast who has a medium level of knowledge. This is because otherwise the final product would be positioned in an extremely niche sector in which "even the most passionate engineer would end up judging the configuration as something very heavy and stressful". The main objective of the company is in fact to make the configuration a moment of extreme usability, considering that one of the key elements of their product is to bring fun, enjoyment, that is the focus on which the entire implementation phase is concentrated, but also the phase in which the customer will be conducting the choices: comfortably, at home, having all the information he needs to make a choice in peace and enjoying the purchase experience to the full. Here we can see a preview of how the Car Configurator will look like on the company website, truthfully resembling the configurator of a videogame:

Figure 42. Bermat Car Configurator platform

Source: Bermat, 2019

The modular and adjustable **MR- Chassis** represents the hardware of the platform, which can also be configured via the website. It can be purchased online and supplied according to the configuration chosen by the manufacturer. It is designed to allow and facilitate custom configuration, starting from the beginning of production by modulating the frame according to the chosen characteristics.

The company's program is to start with the production on 2020, and according to Bermat plans, from 2021 it will be able to offer a totally configurable sports car, which will allow the personalization of the interior and bodywork, already designed with a modular philosophy: "The various modules can be interchangeable, allowing for example to choose a more racing line, with elements such as air intakes or ailerons, or a more classic one, with more harmonious stylistic elements".

The customization, in fact, will be extended not only to the frame but also to the internal and external design, starting from the bodywork up to the interior features such as fabric or leather finishes. The customer has the possibility to select various sub-elements to be able to choose and combine these elements, obtaining final results that have a style "appropriate to the beauty that an Italian car must have". Bermat, for the realization and conception of the internal and external design of the machine, leans on a Style Center in Turin, which is following their project and helping them in the realization.

For what concerns production and delivery times, Bermat has set itself the goal of giving a faster response to the market than today's world of personalization. In fact, for a basic model, from the moment of configuration and confirmation of the online order by the customer, the realization times for obtaining the finished product are around one / two months. This for a basic model and assuming the presence within the production site of the chassis already made for that particular ordered model and also the presence in house of some of components that the customer has chosen already produced and stored. Obviously, according to the CEO, "times are children of what the customer will choose" and depend a lot on the exclusivity of the personalization and the refinement of the materials and selected features. As Matteo says, "if the customer asks us for a gold-made change we can get him the gold-made change" but of course this requires more time to find a supplier who is willing to supply the piece, to establish a relationship with him and for the implementation of the piece. The personalization is simpler in terms of organization and timing if it involves collaboration with suppliers with which Bermat already has solid relationships and for the realization of components that have already been processed and tested on the frame. In any case, the main objective of Bermat is to offer a rapid response to the customer to establish an additional point of differentiation and competitive advantage compared to other car manufacturers.

4.2.5 Bermat – Manufactury 4.0

Once the customer has completed the configuration phase and defined the characteristics of the frame, Bermat moves on to the construction phase. The production of the frame will take place in-house, constituting the core-business of the company, while for the components - engine, battery, brakes, bodywork, interiors and more over - they will rely on suppliers outside the company. At this moment, the company has not adopted industry 4.0 technologies for the internal construction phase of the chassis. The first phase of the realization of the product will be concentrated on the manufacturing of the chassis in a "traditional" way, so there will be a physical workbench on which the metallic components of the frame will be installed. Every single component will be laser cut, obviously with some devices that already allow for joints, and then there will be an expert welder who will take care of the welding of the pieces: the realization of the chassis will have a very artisanal connotation. Manual work at this stage of the manufacturing process is very important because customization at this level is an art still difficult to produce in robotics. In the future, when the development and the production numbers of the chassis will increase, there is the intention to robotize the main parts of the welds, the joints, the chassis itself. What they intend to use in the future for the production of their chassis and other components, so as to further increase the level of customization and micro-modularity, is the use of additive printing in rapid prototyping: metallic and plastic additive printing. Metal additives - metallic 3d printing - will be introduced for the chassis, while plastic 3D printing, already used by its suppliers, will be implemented on additional bodywork components and components related to the interior. For what concern the chassis, the CEO declares that he has not yet applied this technology because it is still too complicated in economic and organizational terms, even considering the state of affairs of the company. The production of the chassis will start by using traditional production methods, but the same frame is already designed and modelled to be printed through additive manufacturing in the future. The timing provided by Matteo to introduce the additive manufacturing to produce the chassis is around two years. As Matteo explains, 3D printers represent an important investment in economic terms, which is subject to a high devaluation, and it is for this reason that the company intends to wait to have the first economic positive returns before making this investment. At this time, however, there are many Bermat partner suppliers that already use 3D printing for some components of the interior, bodywork and plastic material. Among their suppliers, this technology is spreading in a dizzying manner, all their partners working in the automotive segment use 3d manufacturing as their main business, so Matteo thinks of relying on them for the use of this innovation and also in the future in-house implementation. The main advantage found by Bermat suppliers in the use of additive manufacturing lies in skipping the onerous and long phase, both in terms of time and realization, of the molds. With the 3D printers they have the possibility to insert the digital files as per project, give the input to the printer and have as a result the piece printed in a short time. This, for a very advanced type of customization, extremely varied and variable, as in the case of Bermat, allows a much faster response for the market and greater satisfaction of the end customer. Furthermore, there are also advantages in terms of cost, linked to the possibility of avoiding the realization of a different mold every time, simply by creating a file, certainly cheaper, which will then be printed in 3D.

For what concerns the Car Configurator, it does not present 4.0 technologies as Big Data because it would be too expensive in economic terms, but both the hardware and software are designed to have developments in 4.0, such as elements of self-learning about customer behaviour on the configurator.

The Bermat car is also designed to introduce elements of inside connectivity. What will be developed is a type of connectivity linked different from the elements for everyday use of the machine, as we are used to see in most of today's mass-produced cars, but more linked to the purpose, to the intrinsic "*pistaiolo*" nature of the Bermat’s car, to sport driving, to fun. An example of connectivity applied to Bermat cars could be to transmit the performance of the car, such as time, speed and trajectories in real time on the social channels or within the drivers’ community. As the CEO points out, however, that kind of connectivity is a future development that will not be implemented in the short term, when they will focus more on putting into practice and launching their patent on the market.

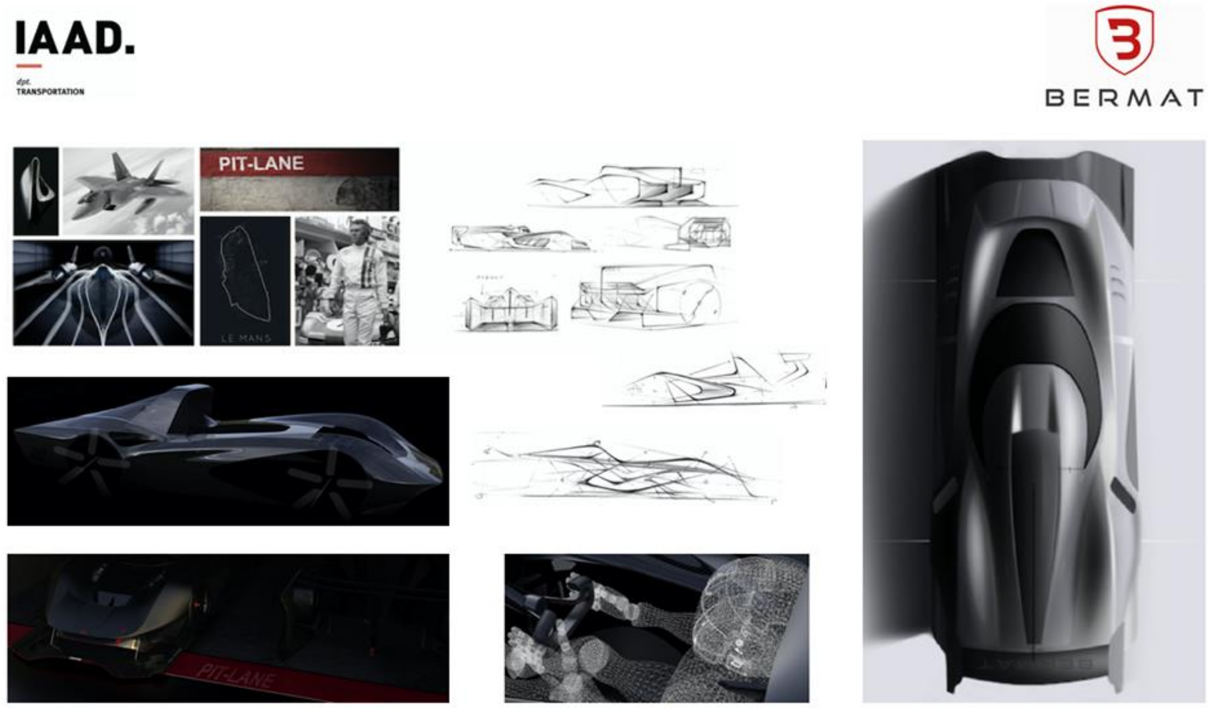
4.2.6 Bermat – Customer Engagement

The company considers consumer involvement in the creative process to be fundamental. According to the CEO, the customer is also part of the product's success and the company's evolution. Just the fact of creating a product design path in which the customer is completely involved is the first step to create engagement and involvement, which then will be extended to other areas. The objective of Bermat is to allow the consumer to be fully involved, for example by creating a community in which he can regularly share surveys, tests, opinions and foster participation in themed events. What Matteo emphasizes is that, being Bermat a niche segment, it is talking to a niche market and not to masses: this allows a direct relationship with the consumer or with a group of consumers that is certainly easier and of greater value. The customer to whom the company addresses with its product is "a customer neglected by today's market, which needs certain answers that are not given to it by the automotive industry, for which it is a lost customer. We want to create answers for the customer in order to offer them an added value that differentiates us from others. Easy to talk about, hard to do, but we're working exactly on it.” Currently the company communicates with the final consumer mainly through the Facebook social channel. Bermat's Facebook community has six thousand followers, many of whom are already targeted customers. Bermat is also present on Instagram, which thanks to its potential represents an important tool for the company. Finally, the company has its own website, currently in the process of being reworked with the aim of making it an interactive site, where the customer can have access to the Car Configurator to start elaborating the car. Bermat's goal is to be able to create a community like Harley Davidson, that is a very strong community, very heartfelt, distinctive, with a strong sense of identification and participation. "The Harleysti are solid, they recognize each other in miles, they have a very long history, it will be difficult, but we hope to get there." Theirs would be a small community of enthusiasts, pilots who organize track events and share experiences, thoughts, doubts, problems and solutions. Bermat wants to focus on creating a community of this type mainly for some reasons. The first is that such a social tool allows them to have a just-in-time response from the market: customer orientation, trends, requests. It allows to stay on the wavelength of the customer's wishes. Not least, a community turns out to be a powerful customer loyalty builder tool. Furthermore, the growing identification of the consumer with the entire Bermat world and the satisfaction brought about by the possibility of owning a customizable object and in which there is a high potential for identification, allows the company to play on the mark-up, especially with the increasing in the degree of customization: for the final consumer the most important aspect becomes the car itself and the satisfaction that comes from owning it, and less importance is given to the price. The company intends to invest in creating a community, first of all by hiring a community manager, that will be in charge on developing the community, managing the collaborations with external partners and brand-ambassadors, enlarging the community and at the same way reaching as many potential customers as possible. The manager will also be in charge of data analysis regarding customers’ behaviours. When we asked Matteo if he had ever imagined a community of consumers who own 3D printers at home, with whom they can create and/or print customizable components for their Bermat car, the answer was "it would be nice to imagine such a future". According to Matteo, it is a possibility that cannot be excluded in the future, which fits perfectly into the Bermat personalization philosophy. "Having us the files, which we send into production through our partners, it would be even better to imagine a future in which it is the customer himself who buys the file from us to print it, thus personalizing the machine at home". The CEO recognizes the importance of people, how feeling part of a group can benefit the well-being of a company and the creation of a solid and united network of relationships, which is an important source of information and ideas for entrepreneurial development. It also recognizes how the times are in continuous evolution, and the new technologies of the industry 4.0 impact in a staggering way different phases of this great industry that is the automotive one, not only for the mass production but also and above all the niche one.

4.2.7 Bermat – Collaboration with external partners

For Bermat, collaboration with external parties is extremely important. First of all, for the realization of this great project, the company has been committed since the first moments of its establishment to creating a relational network mainly with its suppliers, customers and stakeholders. Outsourcing activities are divided into formal collaborations, mostly normal supply-customer relationships and participation collaborations. In fact, some of Bermat's suppliers have become passionate about the project to the point that they have decided to become partners: they are willing to sell the supply at a cost price, as an "investment" in the future of the company. People who like the project and want to become long-term suppliers, because they believe in the future success of the company. Precisely for this reason the CEO is thinking of introducing the Work for Equity formula, in particular with professionals. For example, a reality linked to the world of Marketing will soon enter the Bermat company structure with the Work for Equity formula. Furthermore, Bermat is an extremely open and available reality with the world of University and Research. For example, they collaborated with the IAAD of Turin, where a graduate student, in collaboration with the Turin Style Center, carried out his thesis on the implementation of the design and style of Bermat bodywork (**Figure 43**.).

Figure 43. Bermat collaboration with IAAD for car’s design



Source: Bermat, 2019

Bermat gives a huge importance in continuously stimulating internal creativity. "Creativity is a daily element." Every day, in Bermat, we work in a transversal perspective, and there are always moments in which the company dedicates itself to creativity with contamination from all the areas involved, starting from the simple worker who uploads the company's accounting data arriving to the creative that works on the machine's style.

The Bermat case represents an all-Italian reality of innovation in the automotive sector. The company is a direct testimony of the fact that the end consumer is becoming more and more important in company decisions, at the point of becoming co-designer of the machine. At the same time, the case highlights how additive manufacturing is crucial in the production phase to facilitate the process of customization of the various components. Metal and plastic additives represent a precious opportunity for Bermat and its suppliers to maintain their competitive advantage in the market, both in terms of response to the market and in terms of the quality-price ratio of the product offered.

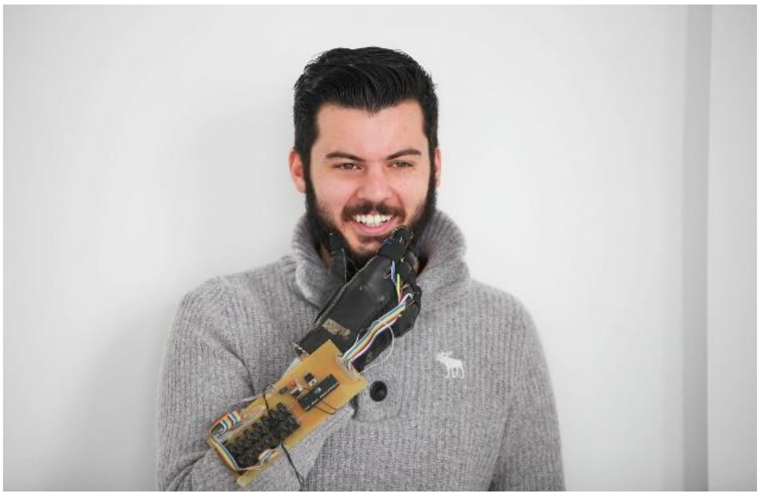
4.3 Rimac - Company Introduction

Rimac is the Croatian Automotive company that has introduced a radical change in the world of hyper cars, demonstrating how the electric car is capable of holding head, and even outperform, diesel-powered machines. I had the possibility to visit the headquarters of this innovative company during my Erasmus experience in Croatia, and it is from this visit that I started to think about my Master Thesis on Industry 4.0 and Product Personalization. Visiting Rimac headquarter is a very impressive experience, even for people that have been working in the automotive sector from years. Mate’s history is one of those stories that were born in the dark of a home garage, driven by the passion and innate creativity of a boy who wanted to experiment and challenge common thinking, creating one of the fastest hyper cars in the world. Rimac presents the case of customization at the level of the luxury market, in which - especially for the first hyper car of the company, produced in less than ten pieces - the level of customization consisted of a One-on-One process of elaboration and configuration with the customer. At the same time this case shows evidence on the importance of Additive Manufacturing especially at the initial stage of the company, to allow for increased flexibility and lower initial investment costs, giving the company the opportunity to think, design and prototype components in-house while asking to the final market, with a considerable cost advantage and with the creation of a strong internal know-how.

4.3.1 Rimac – The History

The story of Mate Rimac begins as the story of a real Maker, who made of the DIY hobby his passion and his fortune. Mate’s passion for engineering and cars started from when he was nothing more than a little child. “I have loved cars since before I could walk and talk. It’s really funny, actually, because no one in my family is involved in cars and I was born in a part of Bosnia that didn’t have that many cars, or even roads — it was mostly agricultural. Because of the Yugoslav wars, we moved to Germany, and my parents told me I was so crazy happy because of all the cars on the road” tells Mate to the newspaper The Edge (Gopinath, 2018).

Figure 44. Mate's first invention, the iGlove



Source: The Edge Communications, 2018

When Mate and its family moved back to Croatia, he finished his education in a technical school, where students are required to build something as their graduation project: Mate developed an electric glove that did away with the need for a mouse and a keyboard (**Figure 44**.) — an idea that was especially useful at a time, when touch screens were not yet prevalent. This ingenious innovation won several local and international awards, and Mate acquired his first patents before he was 18. While no one owns an iGlove today, it was the earliest indication of Mate's eye for innovation, creativity and technical flair. When Mate turned 18, he bought a 1984 BMW E30 3 Series, a car that was four years older than him, to participate in some races (**Figure 45**.). The E30 was barely two weeks old when its engine blew during a race.

Figure 45. Mate with his BMW E30

Source: The Edge Communications, 2018

Rather than a like-for-like replacement, Mate came out with an idea: he considered something totally different. "I was always thinking about an electric car, and I grew up reading about

Nikola Tesla — who was born in Croatia — and I wondered why electric motors in sport cars hadn’t already been done. It’s hard to imagine now, but electric cars then were considered not very exciting. But I wanted to change that — I wanted to make not just an electric car, but one that would kick petrol powered cars’ asses,” he shared. So, he started to work in his parents’ garage to convert the old BMW into an electric race car. But the Croatian racing community weren’t at all impressed from Mate’s achievement, and endlessly jeered Mate. “They used to tell me I was racing a washing machine,” he says, grinning good-naturedly. “I had many issues with my car, but after every race, I fixed each thing that went wrong so after a while, I got faster and faster and that’s when people realised I was on to something — they stopped laughing at me, and would come to the races to watch me instead.” Mate’s success is even more notable considering he was racing against powerful petrol-powered cars. “I won my first race in 2010 — which, as far as I’m aware, is the first time an electric-powered car has beaten a gas-powered one — and in 2011, that old BMW broke several Guinness and FIA records for the fastest accelerating car,” he adds proudly. In fact, he won a Guinness World Record and a Certificate of Record from the Federation International de l’Automobile for the fastest ¼ mile by an electric car made in 11.850 seconds at an average speed of 75.949 MPH. The BWM E30 was the foundation stone for the super sports car and technology company Rimac Automobili. Mate strongly believed that electric propulsion systems could be used to power the new generation of sports cars and make them better, faster and more exciting, and this is why, in 2009, he has started the project with a handful of people as his team. It is in this year that he official founded the Rimac Automobili, headquartered in his home garage in Sveta Nedelja, Croatia, at the age of only 21. In 2011 Mate Rimac emerged from the garage and decided to take his one-man-band show on an intense journey. He was joined by Igor Pongrac, an engineer who worked before making drones for the Croatian army, and by Adriano Mudri, a designer who worked at General Motors, that became de facto employees number two and three, working evenings and nights in their spare time. The switch from a hobby to a real business came when a representative of the Abu Dhabi royal family, familiar with Rimac from his early fame as an inventor, asked to see their automotive work. The guys quickly made a brochure. They went to Abu Dhabi with the brochure and the people from Abu Dhabi said they wanted two cars. As Mate says, “I was like, ‘Great, but there is no car, there is no company’. The next day he called me and asked, ‘How much do you need?’. I had absolutely no idea.” Usually, even the most structured and established car company, with a legion of engineers and big budgets, took a certain amount of time for design, engineers and build a car from scratch. The Rimac trio had a year: they drew up a plan, booked a stand at the 2011 Frankfurt Motor Show — then only 12 months away — and began working in earnest. The task proved more difficult than expected:

even buying commoditised parts such as door handles or headlights was beyond their means, so they had to make everything themselves. That still defines the business: Rimac remains one of the most vertically integrated car companies in the world. Funding was scraped together from family and friends because the Abu Dhabi investors would only pay up once the cars were delivered. Sleeping on sofas or the floor, working through the night and weekends, the team had the car ready for the show. September 13th, 2011, Rimac Automobili made its debut at the Frankfurt Motor Show, unveiling their first proper car, Concept_One. They took orders for just eight vehicles, the last of which has been delivered some months ago. Within some days from the Motor Show, the company almost collapsed. In fact, at the final stages of the funding negotiation, the backers demanded the business relocate to Abu Dhabi before they would agree to inject €4.5m. Without the funding, the carmaker was in danger of folding, but Rimac refused. "It was the best thing I've ever done," he says. The business remains the only carmaker in Croatia. "Educated or ambitious Croatians tend to emigrate to Germany", Rimac says. "When I see all of these people here, doing this stuff, most of them would be outside Croatia if it wasn't for this company." Following the Abu Dhabi setback, Rimac secured a loan of half a million euros by offering everything — the prototype car, the intellectual property and the brand — as security to a local bank. Cash has remained tight in the intervening years, with money for wages or bills rolling in sometimes with hours to spare.

4.3.2 Rimac – The Products and The Market

The company's flagship, the Concept_One, was entirely designed, developed and manufactured in-house. Orders for the eight Concept_One, each with a $1.2m price tag, helped keep the company afloat. Meanwhile, it designed and built electric prototypes for lesser-known vehicle makers, each job bringing in a few million euros (Campbell, 2018). In 2012, Rimac broke 5 Guinness and Fia World Records for the fastest accelerating electric car. In 2013, they developed and tested an all-wheel torque vectoring system and powertrain. In 2014, the Concept_One becomes Fia Formula E's official race director car. In 2017 Rimac company expanded its market on three continents: north America, Europe and Asia. In the same year, Forbes Magazine named Rimac one of the Top 30 Under 30, the 30 best entrepreneurs under the age of 30 of the world and Mate was selected as Croatian Entrepreneur of the Year by Ernst and Young Croatia. It is in 2018 that was launched in world premiere the new jewel from Rimac: The C_Two. The next generation hyper car - boasting a top speed of 415kph — will have a production run of 150 units, priced at $2.1m each. At this moment they are committed in the extensive C_Two development and testing program, for homologation. In the meantime, the Zagreb-based company has 597 employees, and a further, important growth is expected to come in the next year, when they will finish the assembly line production building for the C-Two. “Six months ago, it was totally different; six months from now it will be totally different,” says Rimac. Mate's dream was to show the potential of electric drivetrains and to build the world's most powerful electric hyper car. That is exactly what Rimac is doing today. In less than 10 years, Rimac grew into an electric hyper car manufacturer building the first automotive company in its native Croatia, which has never had a car industry, and very few technology-based ones — that produces cars to outperform the powerful petrol-guzzlers from the likes of Bugatti, McLaren and Lamborghini. In addition to electric cars, the Croatian company produces drive and battery systems for other manufacturers, supplying to some of the biggest names in the industry: Hyundai, Porsche, Aston Martin, Koenigsegg, Automobili Pininfarina, Seat, Volkswagen, and more. The company is vertically integrated with many of the components produced in house, what makes a walk through our facilities fascinating. In June 2018 Porsche AG has invested €18.7m in the technology and electric sports car company Rimac Automobili by taking a minority shareholding of ten per cent. They viewed in the Croatian electric pioneer and his company a strategic partner with whom to advance the future of electric mobility. “This partnership now is an important step for Rimac on our way to become a component and system supplier of choice for the industry in electrification, connectivity and the exciting field of Advanced Driver Assistance Systems”, explains Rimac’s CEO. Rimac cars have stunningly luxurious interiors perfectly match stylised exteriors that are 100% purpose-designed for performance — aerodynamics, safety and technical requirements dictate every aspect of the design. The company combines high levels of innovation and previously unseen technology, and it collocates itself as a luxury company, although Mate is opposed to the idea that electric mobility is only for the elite. “We are not a snobby company making cars for only the billionaires of the world, but we have to start here,” he states. “Once the electric mobility model is more popular, we then have the manufacturing capabilities to make it more accessible”. In time, Rimac’s technology may make its way into everyday vehicles, as customers such as Porsche share the technology with mainstream sister companies such as Volkswagen or Skoda. In the words of a Porsche spokesman, “Rimac’s ideas and approaches are extremely promising”. Rimac attributes much of his company’s competitiveness to its trial-and-error approach in its early days. Old photos of the business show people asleep on sofas, and stacks of batteries, bundled together with wires or cables snaking out at various angles. “This was really, really dangerous,” he says. “High voltage everywhere. It was insane.” Rimac’s inspiration was the father of high-voltage innovations, Nikola Tesla, the pioneer of the electric AC motor, who was born within 200km of the Zagreb plant and whose name adorns the company's boardroom. If the title had not been bagged by Musk, Rimac says his company would have been named after the inventor. Another early brand name was VST, based on v=s/t, the formula for speed (Campbell, 2018).

4.3.3 Rimac – Green, Smart and Connected Car

Rimac's electric cars are not only luxuriously well-appointed, beautifully designed and thoroughly performance-driven but also efficient and environmentally friendly. Translating his technical skills into a successful business was the hardest part for Mate. "Croatia never had a car industry, so this was like the perfect storm — new technology in an industry that was notoriously hard to enter, and I had no money. The odds of becoming what we are today were pretty much zero," he recalls. "I needed to do something to raise funds, so my idea was to work for the industry first instead of in it." His solution was to manufacture components for the electric car industry so Rimac would become self-sufficient. As a result, the company now has two profitable businesses — one that showcases what electric supercars can do, and one that provides end-to-end support for other carmakers eager to get into the electric mobility game. Some two-thirds of their work is in supplying electrical parts, from batteries to powertrains, to the makers of performance cars. It already has an enviable customer list — its technology being found in vehicles from Aston Martin's Valkyrie hyper car to the battery-powered Jaguar E-type Concept Zero (driven by the Duke and Duchess of Sussex after their wedding in May) and an electric hypercar from Automobili Pininfarina of Italy. Electric technology is increasingly important to car manufacturers, which are being forced to develop battery cars as a way of meeting emissions rules in regions such as Europe and China, and also for encountering the always more environmental-friendly customers' requests. "I've had the same opinion for the last five years — it is inevitable that cars one day will be autonomous and fully electric. No one will own cars anymore, nor will they care what is under the bonnet — cars will be a service. Things are going to change rapidly in the next two decades and it will change our lives, like how mobile phones did. Yes, of course, there will still be fans of motor racing and gas-powered vehicles, but electric cars will simply make more sense in the long term because of what cars are becoming," he adds.

“What is the market for electric supercars? Honestly, no one knows. Right now, it is eight Concept_Ones,” says Rimac. However, serious motorists, attuned to the guttural roar of V12 engines, are likely to be attracted by the performance of battery cars (Campbell, 2018).

Rimac’s first electric supercar, the Concept_One, recorder some truly impressive statistics underpinning its performance — 0 to 100kph in 2.5 seconds, a top speed of 355kph and torque of 1,600Nm. "All Wheel Torque Vectoring System" developed and patented by Rimac, has the power to distribute the power to the wheels in accordance with user setup and driving conditions. The car featured carbon ceramic brakes for improved stopping power. Also, the car has the ability to switch the power from front-wheel to rear-wheel drive or to equally distribute the power between all wheels. During the tests, the Concept_One outpaces a Lamborghini Aventador and a Honda NSX, becoming the world's fastest accelerating electric vehicle in 2013. This is because electric cars can draw huge amounts of power from their batteries for short bursts — and the technology is improving. A Tesla P100D Model-S can, in short bursts, produce 500kW of power from a 100kWh battery — what is known as a C-rate of five times. Rimac’s battery for Aston Martin will achieve a C-rate of 120 times, drawing 120kW of power from just 1.3kWh. This will make the Valkyrie hybrid car, which will still have a V12 petrol engine, the fastest road-legal car in the world around a race circuit, its maker promises.

Rimac presented the latest version of its electric hyper car, the “C Two”, at the Geneva Motor Show in March 2018. The new two-seater produces around 2,000 hp and reaches a top speed of 412 kilometres per hour. It has a range of 650 kilometres (NEDC Cycle) and achieves an 80% battery charge in 30 minutes through a 250 kW fast charging system. It is capable of hitting 0-100 kph in 1.85 seconds and is also semi-autonomous. Rimac only plans to make 150 of these cars, all of which were sold out three weeks after the launch. The car will be homologated for the global market and the first deliveries are expected to take place in 2020.

As explained before, Rimac manufactures electric batteries not only for its cars but also for other car manufacturers that trust them because of their high-performance technologies and solid know-how completely built in-house. They work constantly on keep the battery cool over time, since they developed an innovative battery thermal management system. Thermal management of the battery packs is one of the most challenging issues in electric vehicles, especially prominent in high-performance applications. In Rimac they designed, tested and verified different types of thermal management systems for different uses. From liquid cooled, partially sunken solutions for the most extreme demands to the effective air-cooled systems, their thermal management makes sure that all the cells are at optimal temperature ranges. This way the batteries can provide the required performance without sacrificing lifetime. Rimac designs and develops multiple battery packs for different clients on the automotive industry. However, they are not limited to just automotive as they have experience with the nautical and e-bicycle market. For example, in 2013, Rimac founded a new company, Greyp Bikes, a sister company of Rimac Automobili, with the purpose of manufacturing high-performance green bicycles.

Because Rimac team approaches the electric supercar idea from scratch, they have the possibility to develop several ground-breaking technologies like the user interface they developed for Concept_One first, and C_Two then.

Figure 46. C_Two Infotainment System

Source: Rimac, 2019

They elaborated – and are constantly working for improving – a very innovative and interactive Infotainment display controlled through a large central touchscreen. Their in-house IVI – In-Vehicle Infotainment – system is the key for constituting an interactive user-to-vehicle communication and offer the best experience to the final customer.

Understanding the pace of an innovative, dynamic market, they developed an open based platform in order to allow for future development to meet all the market demand. The Rimac's IVI system platform (**Figure 46**.) provides integrated connectivity features and vehicle information tools, all based on the principle of "security first". Thanks to their in-house design team that allows for unrivalled quality, flexibility and effectiveness, they have implemented various IVI systems in many different projects in various markets for different OEMs. From small single screens to large multi-screen projects, from cars to e-bikes and other unique projects. Infotainment system provide basic information like battery level and charging settings and basic services like media player, offline navigation; furthermore, it allows for customization of driving tools, like torque distribution, brake balance, power distribution. Infotainment system allows for the connected experience and data collection and management. As Mate says "We worked a lot to develop an infotainment system very fast, because customers are used to their smartphones that works very fast, so Rimac want to give the same performance in their infotainment system, allowing customers to switch from a tool to another in the fastest possible way".

Connectivity has proven to be the future of automotive industry, and Rimac proved also in this field to be in step with the times. They have created user and OEM platforms to provide their clients and their customers with the tools needed to interact with a single or multiple vehicle, all in real time. Rimac's Integrated Connectivity is a 4G/WiFi M2M – Machine to Machine – System for remote diagnostics, software updates, internet media streaming, web browsing, cloud web interface and remote control via smartphone apps and web interfaces. The M2M Dashboard delivers a wealth of real-time data to the vehicle manufacturer through multiple viewing screens: this provides the manufacturer with extremely detailed data at a high refresh rate. Their advanced tool set and sharing capabilities provide the platform needed to for an in-depth analysis of a single, or multiple vehicles. The car automatically collects statistical data like gearbox rear temperature, cells temperature. The vast amount of data they can collect from customers gives Rimac the feedback which they use to constantly enhance driving skiils and performances of the car. Remote control interface allows the customer to stay connected to its vehicle via smartphone. Rimac has developed some of the most advanced Mobile Applications for various OEM's, providing the user with a smart platform to be able to interact with their vehicle and access useful features such as HVAC Activation, Media Transfer, Service Notifications, Navigation Tools and crucial Powertrain/Battery Information.

Rimac, following the actual automotive trends and developments, is concentrating its effort on the development of autonomous driving projects. It has an entire department working on those innovations. According to Petar Svetac, Marketing Assistant at Rimac, the C_Two will have autonomous driving capabilities which will be used for one of the driving modes of the car: “Driving Coach”. The C_Two will be able to load selected racetracks into its on-board systems via the ‘Driving Coach’ function, offering clear and precise guidance on racing lines, braking/acceleration points and steering inputs. A virtual driving coach with a very practical application and learning experience. Rimac's unique "Driver Coach" is a system designed not to replace but rather „enhance” the drivers’ abilities. Either through race programs or live situations, the driver will have accessible feedback such as audio, visual display and direct methods to assist and guide the vehicle to precision. The driver is informed what is upcoming, where to turn, and how to optimize the vehicles performance, all whilst using additional safety measures.

Their team is developing an innovative ADAS – Advanced Driver-Assistance System – for road going cars using their own proprietary software.

With signature features such as Highway Pilot & City Pilot, safety features such as Driver Monitoring & 360° Vehicle Monitoring, and comfort features such as Valet Parking, they are offering a wide range of opportunities.

The ultimate Rimac creation, C_Two, features a digital driver concept. The car will be compatible with autonomous driving at the fourth level, which implies an almost total degree of automation. This will be possible thanks to 8 cameras, a lidar system, 6 radars and 12 ultrasonic sensors. It comes with a list of driver assistances systems including lane assist and auto braking.

The car is also pretty smart too and uses on-board cameras with facial recognition to open its butterfly doors and starting the engine, dispensing the use of a key.

Rimac also claims the car can read your mood it will play soothing music and soften the ride if it senses your stress or anger. Meanwhile, the car is watching the sky. If it gets foggy or starts to rain, the Rimac will adjust its drivetrain and traction management to keep customers safe.

Developing the autonomous drive and coach drive systems in-house forced Rimac to expand their internal data center and build a new, bigger one. In fact, for the autonomous driving and Driver Coach development, as well for M2M communication, they generate an immense amount of data: they counted a production of 6TB of data per one hour of driving; currently they have 3 petabytes of data storage on eight nodes, but they are expanding to 15 petabytes of data in the new facility.

4.3.4 Rimac – Industry 4.0 and Additive Manufacturing

According to Mate “We want to do lot of things internally and be vertically integrated because that makes us flexible but also because that way we can be very fast: one day we can design it, and the other day if it is not a too complex part we can already have it”. Additive manufacturing, in this sense, is a very helpful tool to allow for internal fast and flexible production of components. This is the reason why Rimac has entrusted himself to some 3D printing providers for the production of the Concept_One. As already explained before in the paragraph, Concept_One was the first company bet, and it required a design, prototyping and production time of one year. In this scenario additive manufacturing was the best solution for helping the team to win the challenge. Two examples of companies that collaborated with Rimac in the production of 3D printed components are Materialise and 3T Automotive (2012).

“We worked hard on the technology of this new concept, but I knew that presentation was the key to initially gaining the attention of the media and the car industry,” says Mate Rimac, founder of Rimac Automobili. “That’s why I turned to the experts who could give it an aesthetic appeal.”

As a result, he collaborated with Materialise to top off the sleek and sporty design with 3D printed parts. One of the main advantages of using AM, according to Materialise, it that it ensures to reach an improved level of design. Another, maybe the best advantage, is the reduced time of development and production, and the increased flexibility – we remind that 3D printing allows to avoid the creation of a mold for each single piece different from another, considerably reducing times and costs. All parts made with the collaboration were delivered on time in smaller projects of less than six to seven working days over a period of one and a half months, which included the steering wheel as well as light guides for LED head and taillights and interior light strips. All transparent parts were produced in stereolithography with a high degree of precision. “Since these ‘components were part and parcel of a very sleek and sophisticated looking object, we knew that every detail would be scrutinised, so it needed to be smooth and flawless,” recalls Hans Vandezande, Sales Manager at Materialise (Materialise, 2012). A further collaboration was made with 3T Automotive, where 3T-am’s polymer additive manufacturing services were used to produce the headlamp and tail-light casings for the prototype of the electric Supercar. Built in Glass-Filled Nylon, they were then coloured black using 3T-am’s permanent surface colouring process by their team of in-house finishers. The Glass-Filled Nylon was utilized because it is a material that offers high levels of strength and functionality within the casings, and Rimac Automobili then hand-crafted the headlights to contain 58 high power LEDs.

Each headlight was equipped with a unique ventilation system to ensure a clear and sharp lens projection. Complex design features are incorporated into the CAD, producing aerodynamic headlights with integrated tunnels and channels.

The aerodynamically shaped lights work together with openings in the carbon-fibre bumper and rear diffusor as the Concept_One cuts through air at speed.

Additive Manufacturing builds parts directly from CAD data, so complex design features could have been incorporated into the CAD and then accurately replicated during the build – so tunnels, channels and voids could be easily built, as well as text or logos on the parts. Thanks to the AM process, designers and engineers were freed up from previous design constraints when creating new parts. AM removes the need for conventional tooling and creates parts that were previously impossible using conventional manufacturing methods (3T Automotive, 2012).

Figure 47. C_Two Carbon Fiber Monocoque

Source: Rimac, 2018

Today they use in-house a CNC machine for the carbon fiber and various 3 axes and 5 axis milling machines. According to Mr. Svetac, “We are using CNC machines and 3D printers in machining parts for our components and cars. This enables us to design and manufacture almost all parts by ourselves, and in short time periods. We are using 3D printers in product prototyping. Since we are very vertically integrated company it enables us to change the engineering design of a part of a component and to almost immediately be able to manufacture and test that change.”

The carbon fiber is the main material utilized for the Rimac car’s production. What’s even more remarkable, is that for C_Two they developed a carbon fiber monocoque, the biggest carbon piece in the industry (**Figure 47**.). It's a carbon fiber monocoque with a structural battery pack integrated – the first one the market built this way. And the battery modules are also structural. Then, it's also a single carbon piece. Just the lower part, without the roof is 2200 sheets (of carbon), and 222 metal inserts. It takes something like two months to build one. The Concept Two introduces a new era in the Industrialization process of the company. In fact, in this year they are moving from the prototype, artisanal production of the Concept_One to a more industrialized larger volumes production for C_Two. According to Mr. Svetac, Rimac is currently transforming from a small volume manufacturer to producing large quantities of high-performance electric vehicle components. "At the moment, most of manufacturing is not automated but this will change as we are moving to larger quantities." Concept_One was not produced in assembly line. They are moving to production line and automation to move the production from 8-pieces Concept_One to 150-pieces C_Two.

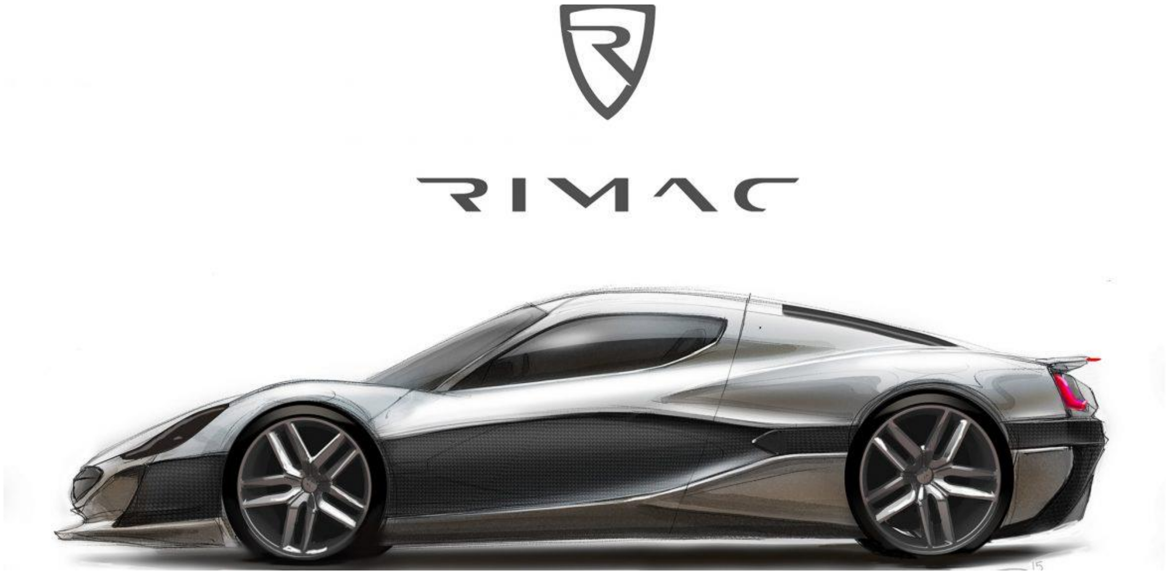
4.3.5 Rimac - Product Customization

Rimac and his team started the production of the Concept_One as a very manual, artisanal work. The car was designed from scratch and hand built. The chassis pieces were weld by hand by special workers, the battery and the electronic connections were laid by hand, everything was done in the best artisanal way. Since it was a very expensive supercar, and because of the very flexible production process, a high level of personalization was guaranteed to the final customers, regarding the exterior and interior design, like colours, materials, any stickers or drawings to be applied or painted directly during the painting process of the carbon shell. As explains Mr. Svetac, since Concept_One was made in only 8 units, it was completely bespoke. Customer could fully personalize their car, from the combinations of exterior colours, amount of visible carbon on the body of the car to the materials and colours of the interior. Concept_One's customers spent time with Rimac Design team and worked closely together to find the combination that was perfectly matched for them. "For some customers we even made possible to be involved in the manufacturing process of decorative carbon fibre parts of their car."

For the C_Two a number of predefined combinations of exterior and interior will be offered, but the customers will also be able to completely personalize the car to their wishes. A customer will use a very detailed and realistic car configurator program to personalize the car.

As we seen before, a good level of customization of the driving experience is also given by the Infotainment system, that allows the driver to choose the desired brake balance, power distribution. Another example that explains which level of detail in personalization they offer, is given by Mate in his YouTube company channel, “We produce by hand personalized keys like if we were jewellers”. They produce internally the keys of the car, and each key resemble the design characteristics of the interns of the car chosen by the customer, for example same colour, same material – like carbon fiber, leather. Every single detail become for them of the greatest importance, to guarantee to the final customer the best shopping experience before and buying experience after.

Figure 48. C_Two Exterior Design



Source: Rimac, 2019

The company gives great value to customers’ involvement in the creative process. As Mr. Svetac says, “We are always open to suggestions from our customers and are happy to hear their ideas and propositions. Close communication with our clients enables us to develop a product which will be best suited to their wishes.”

Because of the dimensions of their final market in terms of volumes, they are not able nowadays to constitute a community of customers. Since hyper cars are not mass-market products, customer base is very narrow, and they are using alternative communication channels to reach their potential customers and receive information from them.

4.4 XEV - Company Introduction

XEV is an innovative EV manufacturing start-up that combines Additive Manufacturing and Smart Urban mobility. Their mission is to reduce the waste of materials, time and money created by traditional manufacturing. They developed industrial 3D printing technologies and processes for automotive mass production in order to give their customers an ultimate user experience through fast product development, customization and flexibility of design. This is the last case that we will present in this elaborate, and it present a company totally different from the precedent two, offering a Mass Customization of a Compact car. This case wants to underline the fact that Additive Manufacturing allows for Product Customization not only for sport and hyper cars, that have a high unitary value, but also for companies like XEV that are offering a car for the masses at a very competitive price. Additive Manufacturing revolutionize the field of personalization as we are used to refer about, showing that it is possible to offer mass customized products to a potentially infinite and varied consumer base. At the same time, XEV is connecting the Additive Manufacturing with Smart Mobility, moving toward the Car Sharing trend, that is growing faster in the last years, introducing a new perspective on the entire car manufacturing industry.

4.4.1 XEV – The History

The X Electrical Vehicle, or XEV, was born from the active collaboration between the XEV precisely, an Italian startup based in Turin, specialized in the creation of electrically powered cars, and Polymaker, a Chinese company that made 3D printing one of its core business. The start-up founded by Lou Tik, manager who headed for ten years in Turin Jac Italy, has three angel investors coming from Italy: Moschini; Teoresi, an Italian engineering company and Comec, a company of Federmeccanica president Alberto Dal Poz, who provided the spaces for the construction of the first prototypes of the car. Polymaker played a key role in the project, taking care of all the parts related to 3D printing and materials. According to Simon Krechmar, Head of Product Development at XEV S.r.l., their idea was to "use additive manufacturing in order to disrupt the conventional automotive production". The idea came from many years of working in the automotive industry: each person in their founding team has at least 10 and more years of experience in large automotive OEM in Europe, Asia and USA. XEV, the Italo-Chinese start-up whose mission is to reduce the waste of materials, time and money created by traditional production, by combining additive manufacturing and smart urban mobility, has developed Yoyo, a low-impact city car designed to tackle the needs of urban mobility. Zero wastage of production and customization, maximizing the use of Smart Data and offering an unparalleled customer experience: these are the goals that XEV wants to achieve. And to do so, it exploits the advantages of Industry 4.0, that is the trend of industrial automation that integrates some new production technologies to improve working conditions, create new business models and increase the productivity and production quality of the plants. Company's core values are defined to be universal customization, waste reduction, customer connection. Their principal goal is to invest on the benefits of Industry 4.0 in order to reach Zero manufacturing waste, zero cost of customization, maximize the use of Smart Data and provide ultimate customer experience. According to Mr. Krechmar, their main target markets are Europe and Asia, in those areas that require innovative electric urban mobility.

4.4.2 XEV – The Products and The Market

The product portfolio of the XEV company is divided into Low-Speed cars and High-Speed cars (**Figure 49**.).

Figure 49. XEV Electric Vehicle range

Source: Xev, 2019

It actually consists of two electric models, the Yoyo, that is the urban mobility innovative car, and the IEV 7 S, their high-speed electric car produced in China by Jac Motors.

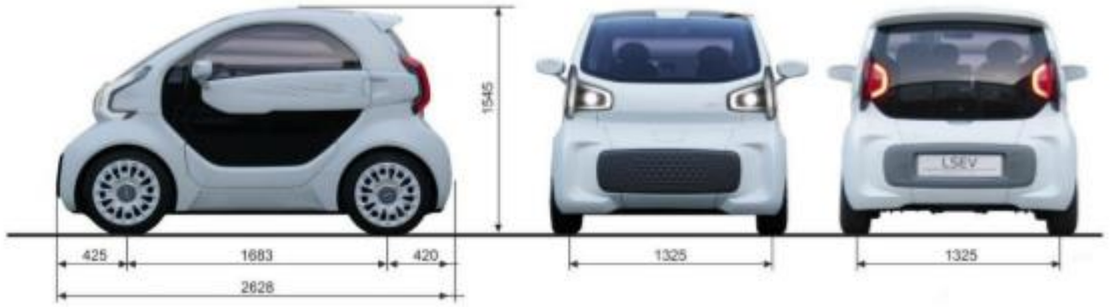
- **High speed car - IEV7S**

The IEV7S is the high speed, 5 seats car of XEV produced by Jac Motors. It has a maximum speed of 130km/h, and it takes 11 seconds from 0 to 100km/h. It has a driving range of 300 km calculated on a basis of 60km/h constant speed. The time required for a slow charge is 5 hours, while the fast charge only took 1 hour. It has an advanced platform layout: the battery is located under the chassis, which lowers the center of gravity and allows for more space. The car has the advantages of compact size, light weight, reliable operation, high power density and good speed regulation. Furthermore, it has elevated safety standards, starting from the configuration of the vehicle body structure and also for what concern the battery safety. In fact, the battery is covered with five layers in order to insulate the voltage and avoid disasters in case of a collision. The car is provided with a liquid cooling technology system that ensures that an explosion or fire of a single cell will not lead to explosion or fire of whole battery package. Finally, the car is equipped with the best accessories both for interiors and exteriors, and it is provided with different guide assistant tools and connectivity technologies.

- **Low speed car – Yoyo**

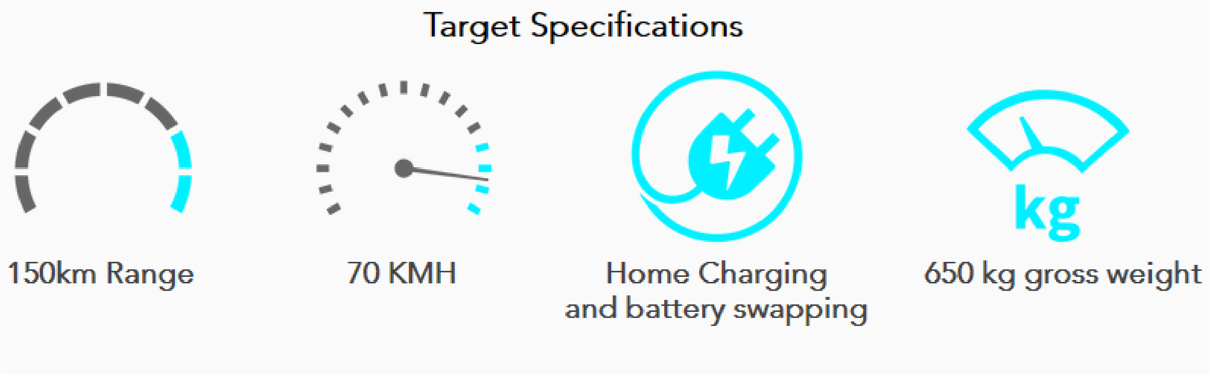
Yoyo is the low speed, high technology car by XEV (**Figure 50**.). Small and agile yet spacious and safe, the Yoyo is a low-speed electric car designed to tackle the demands of modern, urban life. From the simple and compact shape, vaguely reminiscent of a Smart, the Yoyo (whose initial project was called LSEV, or Low Speed Electric Vehicle) is the ideal car for city traffic and is designed in a smart mobility perspective.

Figure 50. XEV Yoyo



Source: Xev, 2019

Figure 51. Yoyo Target Specifications



Source: Xev, 2019

The XEV prototype is the first fully functional prototype by XEV with all exterior and interior parts made with 3D printing technologies. The prototype powered by two 8kW in-wheel motors, has a maximum speed limited to 70km/h and has a LiFePO4 battery with capacity of 9.6kWh, rechargeable both at home and at designated charging stations. They use high quality Lithium batteries in all their vehicles (**Figure 51**.). This not only guarantees a reliable and long-lasting performance but also keeps weight to a minimum, meaning users can go further on every charge. The YoYo falls into the category of heavy quadricycles: it does not exceed 70 km/h top speed and weighs 450 kg – 650 full loads, so it can also be driven by sixteen-year olds and accommodates two passengers. The declared range, achieved during the tests, is 150 km, more than enough for journeys from home to work and even for trips out of town. In addition to the important performances, the city car has the absolutely competitive price on its side: in fact, we speak of a base price of around 8 thousand euros. XEV urban electric vehicles combine a flexible modular chassis, beautifully designed 3D printed interior and exterior panels together with a comfortable, easy to use driving experience. The style of the vehicle can be updated and changed easily for a cost of an iPhone upgrade.

According to Mr. Krechmar, their YOYO car is an urban electric vehicle for personal, company fleet and car-sharing use. It is taught to address a very diversified consumer target, starting from the single person that wants the car for its own use, arriving to companies and society that could utilize this car for giving a car sharing service or for their internal employee’s mobility.

Looking at the reports, XEV already sold 7,000 Yoyo in pre-orders. The car aroused interest among some Italian big companies, first of them Poste Italiane and BNP Paribas. Poste Italiane could collaborate with XEV in order to design and develop the last mile delivery vehicle, personalized on the basis of the needs and requirement of the Italian mail delivery service company. Another company that showed interest in the new car is the BNP Paribas, that could implement a new fleet of low-cost electric cars for his car sharing service Arval. Those example gives a broader view of the potential customers of the Yoyo, that is thought to be adapted and personalized for many different categories of end users.

Alberto Dal Poz, president of Federmeccanica and one of the three ‘angel investors’ of XEV, presents Yoyo as follows: “Printing a car means moving away from the logic of the assembly line: it is a cultural challenge and for this reason we have accepted it. We are a company that produces components and we realize that in the future this new approach will transform the rules of the game: the number of members will in fact change from three thousand to less than two hundred ".

Diego Tornese, Teoresi's Chief Corporate Development Officer and another XEV investor, adds: “It will be a small vehicle with sufficient autonomy and performance to move with agility in an urban context, which can be used in a car sharing perspective and multimodal transport. From this point of view, 3D printing will be a great help: in fact, every single component will be customizable in detail”. A machine that comes to life in three days: "The costs - continues Tornese - will be reduced by 70% and production times by 80%, since the set-up of the production and set-up line is completely cut. The whole cycle will not exceed three days ". A car, therefore, tailor-made for the customer, thanks also to the collaboration with Polymaker, one of the best producers of material in 3D printing worldwide (auto.it, 2019).

4.4.3 XEV - Additive Manufacturing

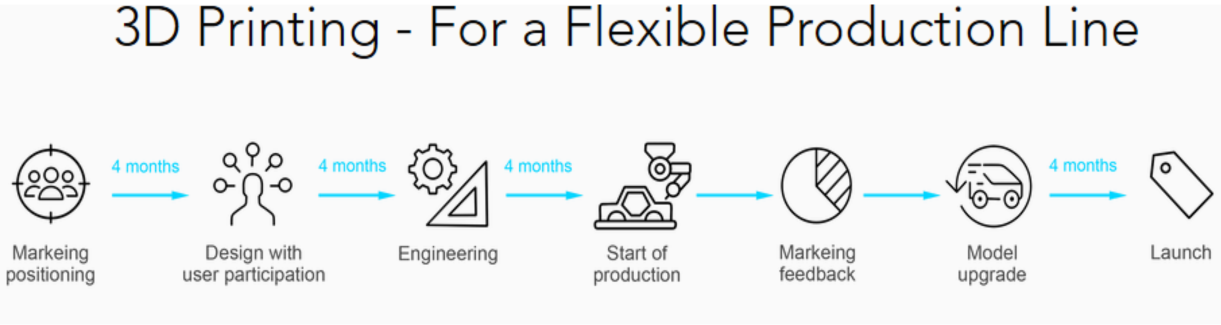
The Xev YoYo car project is based on establishing a principle of efficiency at all levels, starting from the production process. The first, very demanding, bet is to reduce the plastic parts used to build a car from 2,000 to 57, compared to vehicles made by traditional manufacturing, so as to reduce development time by one third (**Figure 52**.). “Developing a new model generally takes 3 to 5 years, with the technique used by XEV ranging from three months to a year”, confirmed Luo Xiaofan, founder and CEO of Polymaker, a Shanghai company responsible for Research & Development of materials for the 3D printed car.

Figure 52. Components of Xev Yoyo compared to Components of a normal car

Source: Xev, 2019

All without giving up a distinctive and recognizable design, with stylish details that respond consistently to the productive needs of additive manufacturing and reflect new technologies. XEV has developed industrial 3D printing technologies and processes for automotive mass production. They use 3D printing to give their customers an ultimate user experience through fast product development, customization and flexibility of design. 3D printing eliminates the need for model specific tooling and allows virtually limitless personalization. Yoyo is properly designed to maximize the benefits of 3D printing technology. All non-structural parts, except the chassis, the seats and the windows, are 3D printed in a low cost, environmentally friendly material PLA which allows unparalleled flexibility for personal customization of style and functionality. With the use of 3D printing technology, the manufacturing and factory costs are greatly reduced, and product development lead times significantly shortened. XEV takes a truly green approach to the entire vehicle development, not just the power source. In fact, another inherent benefit of the additive manufacturing process is the massive reduction of wasted material which is both better for business and better for the environment. Thanks to the use of PLA - a completely biodegradable plastic made from a renewable corn source - the leftover waste is 100% recyclable. PLA does not produce any toxic fumes during production process, unlike other petroleum-based plastics like ABS. All this results in a final product that is kind to the environment and has deeper, more reliable eco-credentials than virtually any other vehicle on the road today.

Figure 53. Additive Manufacturing Production Line for Yoyo



Source: Xev, 2019

The use of high-quality specific material for 3D printing allows high mechanical strength and unique aesthetic solutions. Within XEV they adopted innovative printers created for the production of large-size models using incremental technology. Their printers work in FDM - Fused deposition modelling – technology, that results in the highest printing precision, speed and stability. The 3D printers are accompanied by a totally automatic post processing line, to guarantee efficiency, precision and quality. Traditional methods of producing cars typically involve large, complicated molds and tools that are not only expensive, but also part-specific. The main advantage of introducing additive manufacturing is that it virtually eliminates the need for such limited and resource intensive tooling, resulting in a flexible and efficient manufacturing process. This technology allows for fewer components, faster technical updates and significantly reduced production cycles. It also dramatically reduces production costs meaning the savings can be passed on to customers in terms of lower prices for the final product. Thanks to a pre-designed standardized chassis, the 3D pieces can be modified and changed with significantly less re-engineering. According to Mr. Krechmar, “Additive manufacturing allows us to reduce waste, reduce time and greatly cut investment costs. It also gives us great flexibility of design.”

Since additive manufacturing is a new and growing technology with many positive and negative aspects, XEV wants to make sure to be able to handle any difficulties associated with this technology by leading the best experts in their respective fields in the core team. Their knowledge, experience and professional connections will ensure the company will be able to stay at the forefront of all the relevant technologies. A good example of this is their additive manufacturing and robotics expert Roberto Moretti who is currently working on the next generation printers that will triple the speed of printing within the year and will be the first in the world to use multiple print heads for industrial production. Since early 2017, XEV has also been working in partnership with Polymaker, one of the world's leading manufacturers and innovators of 3D printing materials in order to develop new materials for their vehicle production. Together they have developed and tested dozens of kinds of engineering eco-plastic materials for XEV to meet their needs of practical applications. As a result, 3 crucial achievements have been accomplished. XEV achieved the decreasing in the plastic parts and number of components to 57, and the finished Yoyo weighs only 450 kilograms, much lower than similar sized vehicles usually weighing between 1 and 1.2 metric tons. This switch of production leads to more than 70 percent reduction of the investment cost in comparison with a traditional production system. Conventionally the R&D process of a car model takes about 3-5 years, but it only takes XEV 3-12 months to finish a new design. They also had to optimize the chassis, electronics and the 3D printed plastic parts in order to comply with European safety standards and EU homologation requirements. As the vehicle components are being developed for mass production, they had to develop a robust supplier system with components sourced in Europe and China, where the production sites will be.

Ford, the first to experiment additive manufacturing since the 1980s, claims that 3D printing is suitable for small car series. Or, on a large scale, to produce only individual components, such as spoilers. Instead it would be too slow for mass production. The XEV, evidently, is of a different opinion and has succeeded, thanks to additive manufacturing, in creating a model of city car that has completely overturned the rules and numbers of normal cars. Many cost items have been knocked down: from the production chain, which will now see a final 3-day timing for the simple construction of the components. The additive manufacturing applied to Yoyo for mass production will represent a true 4.0 revolution in the automotive sector. As Mr. Krechmar said, they did not stop the innovation with the implementation of additive manufacturing. They are also working on other Industry 4.0 tools, such as robotic post-processing and artificial intelligence. They completely understood the importance and the advantages related to adoption of new technology 4.0 tools and systems, and they are very determined to introduce them in their business model.

4.4.4 XEV - Product Customization

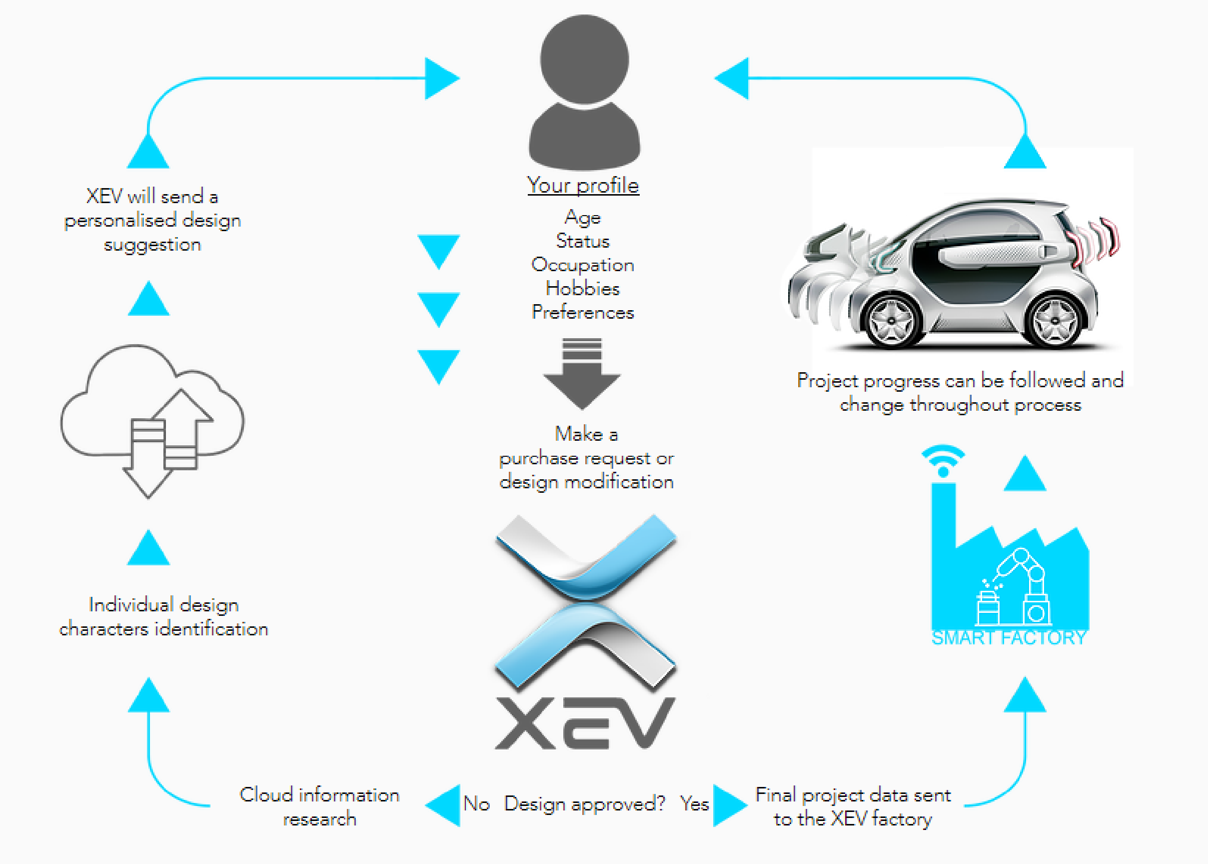
XEV introduces the basis for creating a new kind of relationship between smart manufacturers and end users. Although what attracts customers the most would seem to be aesthetics, as well as savings both in terms of time and in terms of cost, XEV represents the first milestone of the new revolutionary era of the automotive manufacturing industry. The electric car is, in fact, developed with the C2M (Customer-to-Manufacturer) production, one of the main objectives of the Industry 4.0 strategy.

3D printing allows the company to add a new dimension to the buying process by giving the customer choice and allowing him to participate in the design process. They will allow customers the option of personalizing their vehicles in a variety of ways, from simple colour and texture choices to a larger, more elaborate changes with the use of interchangeable modular components that suit their tastes and needs. By doing so, customers will feel engaged and passionate about their vehicles, and when people are passionate about the things they buy, they tend to build a positive association with that brand as well.

XEV offers the customer the possibility to customize his car before it is even realized. Indeed, 3D printing eliminates the need for model-specific tools and allows virtually unlimited customization. XEV urban electric vehicles combine a flexible modular chassis, interior and exterior 3D printed panels. The vehicle style can be updated and modified easily.

The **Figure 54.** shows the customization process for a Yoyo car. The process starts when the customer makes a purchase request or a design modification request. Depending on the features and the complexity of the modifications required, the company will approve or not the design. If the design will be approved, the final project data will be sent to the XEV factory and the production phase in additive manufacturing will start. In a very short period of time the customer will have the end product available. There is another possibility: the company, after receiving the modification and customization request, can decide to reject the design because it needs further implementation by the company to fit the production process standards. XEV will perform a research of information on the data cloud and will develop an individual design project. The personalized design suggestions will be sent to the customer, and in case it will be satisfied by the new project, they can go through the next step, the production and finally the delivery. “Do not compromise, customise” is their motto. In fact, they are providing personalized solutions to any kind of customers, both individuals and businesses. Whether there is a particular colour scheme or a completely customized specific vehicle, their flexible production methods allows for the realization of a potentially indefinite number of combinations and configurations within a shorter timeframe an at a significantly lower cost.

Figure 54. Yoyo Purchase Request Process



Source: Xev, 2019

According to Mr. Krechmar, “Additive manufacturing allows us to customize exterior and interior plastic parts based on customer’s requirements.” With additive manufacturing there is no need for expensive production tools that require 3-6 month to produce. They can do straight from 3D data development to production, this way saving time and money required for tooling. “We will have deep collaboration with business customers that require specific designs and features. In the future we plan to expand our design collaboration to individual customers through large design database”. They work closely with their partners to create vehicles that fit their specific requirements. “The benefit to our customers is great flexibility of design and unmatched customer service.”

For what concerns XEV communities, at the moment it is active on Facebook, Linkedin, Instagram, as well as directly through their website. In the future they plan to unveil a more direct online customer community platform, since they recognize the importance of people engagement at each level.

4.4.5 XEV - Green and Connected Car

Besides being a completely electric car, equipped with high-quality lithium batteries, the Yoyo has some features of the connected cars. With YoYo, XEV provides a "swapping battery" system giving maximum flexibility of use and market positioning through automatic swapping and vehicle localization or with multi-service systems organized by car-sharing and renting companies. According to Mr. Krechmar, “Our YOYO car will have internet and GPS connectivity. We plan to introduce smart navigation tools in car sharing vehicles in certain cities in order to enhance city tourism experience. The car has very flexible platform so in the future we will also introduce other smart driving tools and features.” The goal of the company is to implement connectivity tools based on the final purpose and final users of the cars. For example, companies offering car sharing services will need some particular connectivity tools that are completely different from the ones could ask for a private owner. At the same time, other companies like Poste Italian could ask for further different tools of connectivity. A further implementation of XEV, aimed at reducing the costs of managing the final consumer, lies in the idea of inserting a screen in the rear window to transmit advertising messages. The announcements will be static when the car is moving, to avoid distractions, and dynamic when the car is parked. An evolution of the most classic of advertising media, the out-of-home, which reaches consumers with targeted messages through an unprecedented and captivating media, an ambient advertising: its further strength lies in the originality of the advertising message and of the vehicle used to communicate it. This continuous roller of spots does not affect the autonomy of the car: at full capacity it absorbs about 20 percent of a full charge daily. It is therefore evident how accepting to turn your car into an advertising panel will allow customers to amortize the usage fees and use YoYo practically without incurring in any costs: a strong and attractive topic.

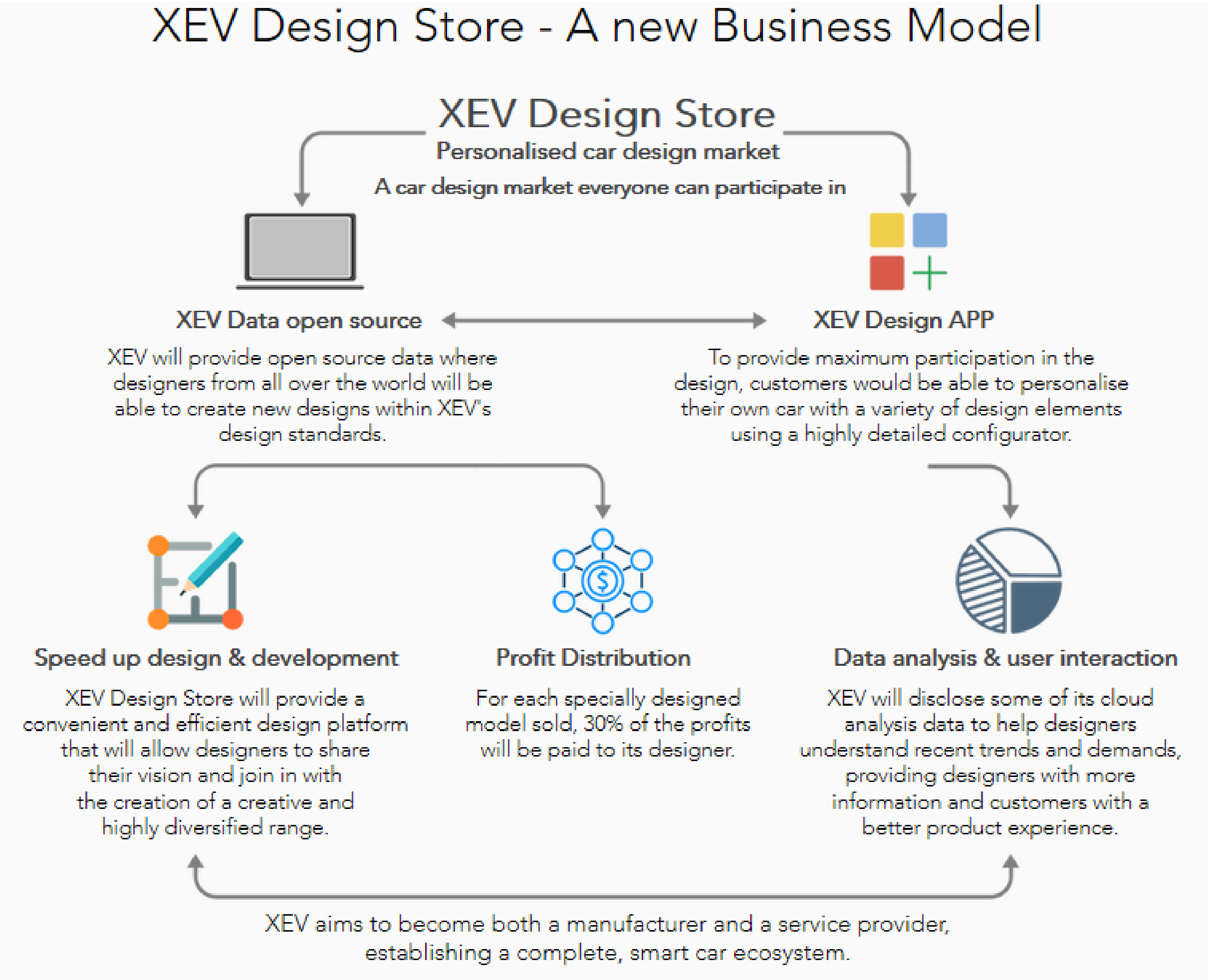
4.4.6 XEV – A new business model

XEV not only implemented a completely new way of manufacturing cars, but also introduce a completely revolutionary business model (**Figure 55.**). They developed an innovative Design store, based on the principles of open innovation and co-creation: a car design market everyone can participate in. First of all, there is a XEV Design App, that is the formal car configurator, that guarantees easy access to the customers for a rapid and efficient personalized configuration. The app offers a broad range of possibilities with a variety of design elements, resulting in a high-detail configurator. At the same time XEV will provide an open source data platform where designers from all over the world will be able to create new designs within XEV's design standards and upload them on the platform. XEV Design Store will provide an efficient platform where designers could share their vision, ideas, and join in with the creation of a creative and highly diversified range of car designs. XEV ideates also a form of remuneration to enhance designers' participation in order to let them collaborate with the company and post their ideas on the platform: for each specially designed model sold, 30% of the profits sold will be paid to its designers. Furthermore, XEV will foster collaboration by disclosing some of its collected cloud analysis data in order to help designers understand recent trends and demands to facilitate their thinker and design activity and at the same time ensure customers a better product experience and satisfaction.

Is all this a reality now? Almost: according to Mr. Krechmar, their project is currently in product development stage and they will start with commercialization for mid-2020; the intent is to reach the manufacture of 10,000 vehicles and then move on to 50,000 in 2021 and, from 2022, to 80,000.

However, already this summer, the new Italian brand began to propose the high-speed model of the range of electric cars produced in China by Jac Motors: iEV7S. But already today it is possible to come across the first prototypes of the small YoYo, to whose development works an Italo-Chinese team in the headquarters of Alpignano (TO) waiting for the new dedicated plant to be completed, again in the Turin area. The cars, then, are already visible and can be purchased from the Tecnicars dealer, exclusive distributor for Piedmont. This is the first XEV single-brand dealer that have been inaugurated immediately after the Turin Motor Show, on June 29, in Via Botticelli, 80 in Turin.

Figure 55. Xev Business Model



XEV Design Store - A new Business Model

XEV Design Store

Personalised car design market

A car design market everyone can participate in

XEV Data open source

XEV will provide open source data where designers from all over the world will be able to create new designs within XEV's design standards.

XEV Design APP

To provide maximum participation in the design, customers would be able to personalise their own car with a variety of design elements using a highly detailed configurator.

Speed up design & development

XEV Design Store will provide a convenient and efficient design platform that will allow designers to share their vision and join in with the creation of a creative and highly diversified range.

Profit Distribution

For each specially designed model sold, 30% of the profits will be paid to its designer.

Data analysis & user interaction

XEV will disclose some of its cloud analysis data to help designers understand recent trends and demands, providing designers with more information and customers with a better product experience.

XEV aims to become both a manufacturer and a service provider, establishing a complete, smart car ecosystem.

Source: Xev, 2019

The XEV plan is to provide companies and manufacturers with a standardized industrial 3D printing production technology solution. The market effect of XEV 3D printed electric vehicles will force more companies to see the huge potential in industry 4.0 and additive manufacturing. In a certain time and provided certain conditions, the entire manufacturing industry will shift towards industry 4.0 and additive manufacturing. As the manufacturing industry evolves, XEV will be at the forefront of the industrial additive manufacturing and will be able to provide 3D printing solutions to the automotive and other industries. Currently, the Chinese automotive manufacturing industry relies heavily on plastics injection molding, metal stamping and other traditional manufacturing equipment. As the automotive industry will start the rotation to industry 4.0, XEV will be able to generate large revenue from 3D printing equipment sales.

4.5 Exploratory Analysis on Maker Communities

The first part of this analysis focused on presenting three cases in the automotive sector that confirmed the trends described in the literature and showed a practical example of how industry 4.0 and in particular additive manufacturing is particularly connected with the possibility of companies to offer the final consumer a shopping experience and a final product with a certain degree of customization. The choice of a qualitative study was dictated by the desire to give real meaning to reality by putting in evidence what is characterizing the world of large automotive related companies to the context in which they are inserted, adopting an internal perspective that allows an exploration from the point of view of the company itself.

In the second part of the analysis we wanted to focus the attention on the demand side, and therefore on the consumer, in particular by investigating within those Makers communities frequented by fans of the additive manufacturing world, who offer a point of view of the phenomenon different from what a company can do. The ultimate goal of this exploratory research is to provide a greater understanding of the phenomenon underway, of which the Makers and 3D printer hobbyists are the main protagonists. The goal of this research is also to try to understand the 3D printing habits of users and their familiarity with the world of automotive and product customization. In the following paragraphs will be presented the structure, the methodology and finally the results of the research.

4.5.1 Methodology and survey

The exploratory research started with the creation of an ad-hoc questionnaire (**Appendix D**) which was administered to different communities, compiled anonymously, with the aim of outlining a general picture of the phenomenon. The questionnaire was developed using the Google Forms platform and consists of five sections divided by topic of investigation. Most questions are closed or multiple-choice. It was considered necessary not to ask open-ended questions due to the greater speed of compilation and ease of consultation, considering that its administration would have taken place to a sample not always interested and therefore willing to spend little time in completing it. This choice has also allowed an easier analysis of the data as they are structured. The types of questions presented in the questionnaire are the following: multiple choice questions and the possibility of a single answer; questions in the form of a matrix in which values must be expressed, on specific scales, in correspondence of a group of variables; questions where a number must be indicated. Finally, there are some open questions to report extremely variable data that cannot be placed within a predefined group of choices as the specific work activity, the place of origin, the community of belonging.

The first section deals with general information. Questions 1 to 7 are intended to outline a demographic profile of respondents, ranging from age, country of origin, education.

The second section focuses on the activity within the communities. Questions 8 to 17 aim to investigate the relational habits of users within their communities, and to introduce a first survey of the relationship between the community and the automotive sector.

The third section focuses on the automotive sector; questions 18 to 20 seek to investigate users' knowledge in the automotive sector and their attitudes regarding the new green and connected car evolutions.

The fourth section is a focus on the world of additive printing and users' printing habits. The questions from 21 to 30 firstly want to understand how many users within the communities have 3D printers, what is their habit of using 3D printers and during which design and creation phases they use them.

The fifth section is dedicated to better understanding the world of FabLabs and Makerspaces and whether these environments have connections with the participants of the makers' community.

The last question has the goal to understand to what extent the users' maker activity is connected with their work activity, if the approach to the maker community is a continuation of work and entrepreneurial projects or if there is a passion to the additive manufacturing also coming from completely different working contexts and knowledge backgrounds.

4.5.2 Sample Description

The analyzed sample includes respondents from different parts of the world, belonging to several Makers communities. The collection of answers had a total duration of about a month and reached a total of 37 respondents. As previously explained, the questionnaire was administered within Maker online communities, both Italian and foreign, and this is the reason why we collected international responses.

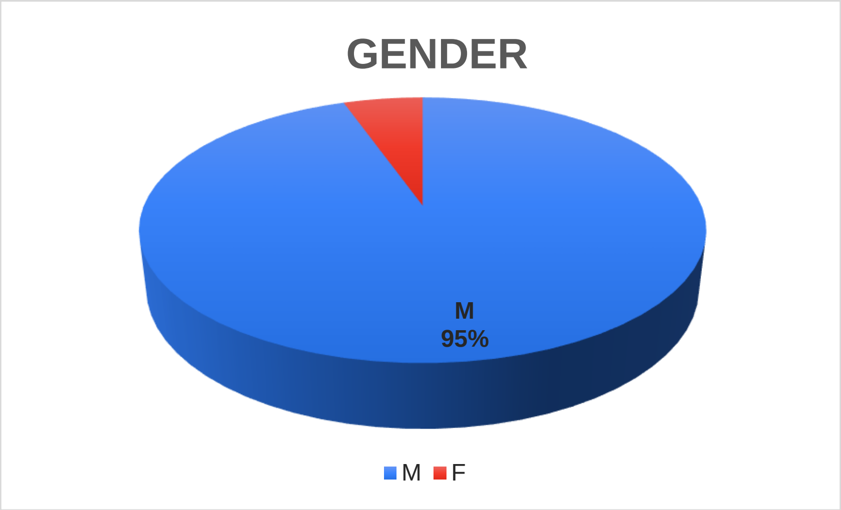
The Communities investigated are:

- *Hackster.io*: one of the world largest community for hardware and software developers. It groups together more than 1,100,000 members and more than 19,000 projects divided by fields, including the automotive one. "*Hackster hopes to facilitate the creation of solutions that make today's world a smarter, healthier place and support the livelihood of tomorrow's generation*."
- *Instructable*: Instructables is a community specialized in Do-it-yourself projects that are frequently uploaded and created by users, which other users can comment on and whose quality they can classify. It was created by mechanical engineer Eric Wilhelm and launched in August 2005.
- *3D Printing Car and Bike Parts*: It is a Facebook community with 438 members that shares the same interest and passion in Cars and Bikes and are fascinated with how 3D Printing technology is and can be used to reproduce car and bike parts.
- *Stampa 3D Forum*: Stampa 3D forum is one of the most famous Italian community of 3D printing. The community connects the world of beginners and enthusiasts with the world of professionals and offers a vast forum where each member can connect with other participants and introduce discussions on various topics.
- *Stampa 3D Italia*: This is a Telegram community of 760 members where passionate of 3D printing can share, comment, discuss and propose new ideas for 3D printing developments and projects.

Within each community, where possible, the administrator was contacted, and it had been asked him to disclose the search among its members. In those cases, when it was difficult to communicate with the administrator, the questionnaire was published inside the various sections of the community, after having regularly registered within the same community. To facilitate the compilation among the members, two identical questionnaires have been created, except for the language: one in Italian, distributed within the Italian communities, and one in English, distributed within the international communities.

The analysis is introduced analyzing the first demographic data. Respondents are almost all men: 95% of respondents are males (**Figure 56**.). This indicates that the Makers communities have a mostly male participation, and that men are the most likely to approach DIY activities.

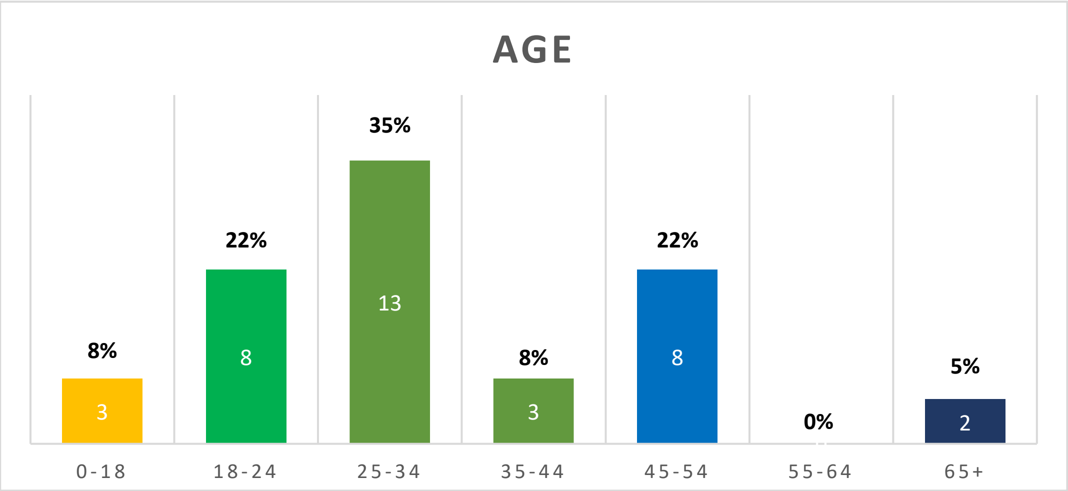
Figure 56. Sample Gender



Source: Own Elaboration, 2019

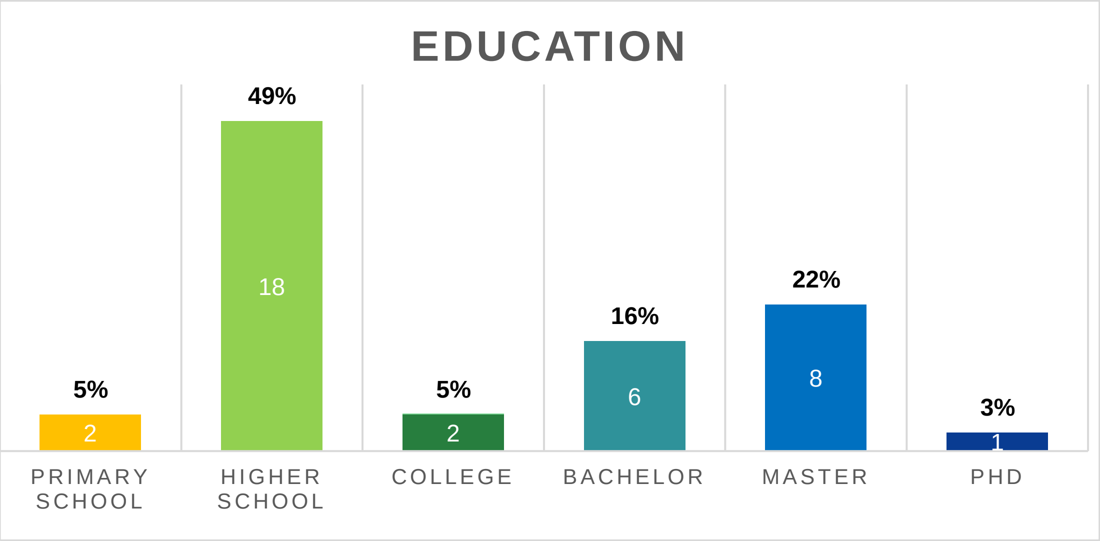
For what concerns the age, the questionnaire was addressed to people of all ages, that were divided into seven age groups: 0-18 years, 18-24 years, 25-34, 35-44, 45-54, 55- 64 and finally over 65 years. The results are not surprising: in fact, around 57% of respondents belong to the 18-34 age group, of which 35% are in the 25-34 age group (**Figure 57**.). This result can be motivated by the fact that young people can have more confidence and competence with the Internet and with new technologies and therefore represent the majority of the members of an online community. The second age group with a noteworthy participation is the 45-54 bracket, of which 22% of respondents are part of. It is surprising that two respondents are part of the 65+ group, retired enthusiasts of Additive Manufacturing, one of whom is even the administrator of the 3D Printing Facebook group.

Figure 57. Sample Age Distribution



Source: Own Elaboration, 2019

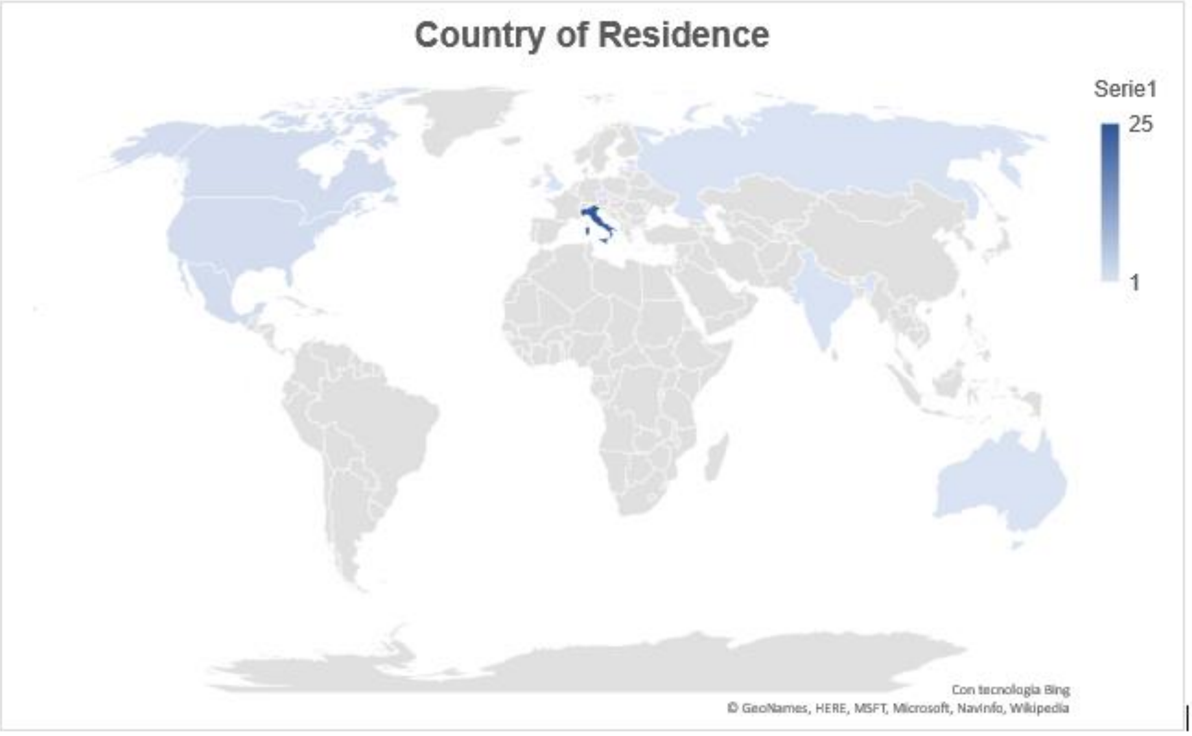
Figure 58. Sample Educational Level



Source: Own Elaboration, 2019

Regarding Education, more than half of the respondents - 54% - finished their studies before university (**Figure 58**.). Of these, 49% have a level of education equal to high school. Only 22% of respondents continued their studies up to the Master's degree, and only one respondent has a PDh. This shows how the world of Additive Manufacturing is easily accessible to an audience of any age and any level of education.

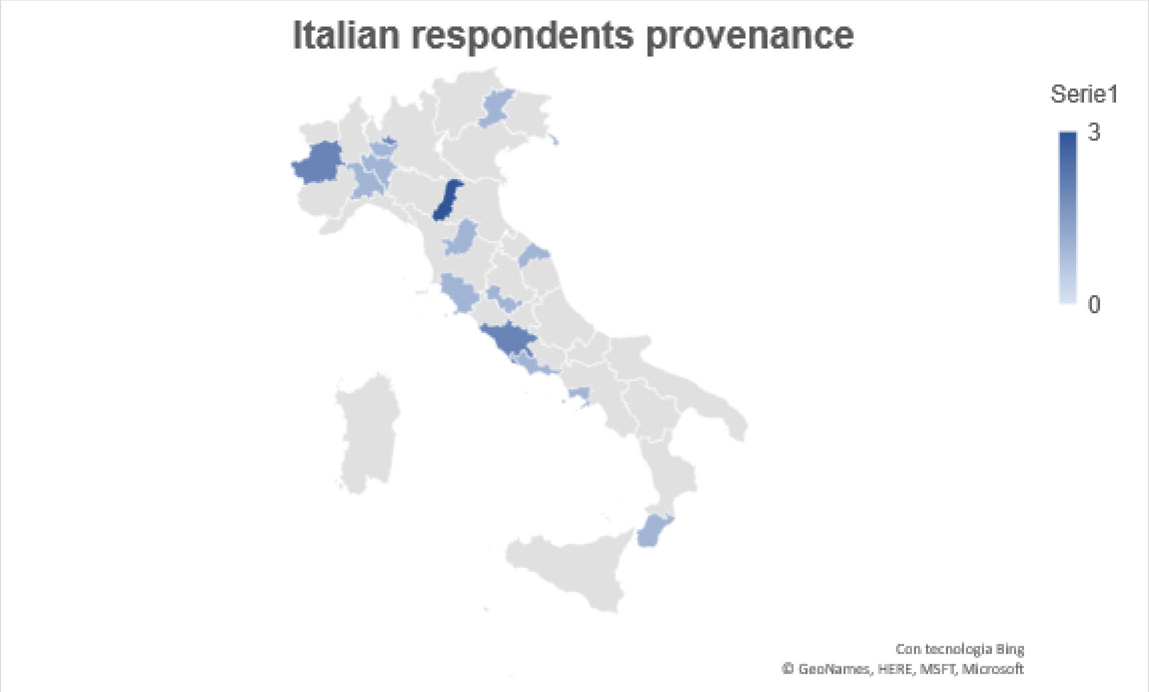
Figure 59. Sample Country of Residence



Source: Own Elaboration, 2019

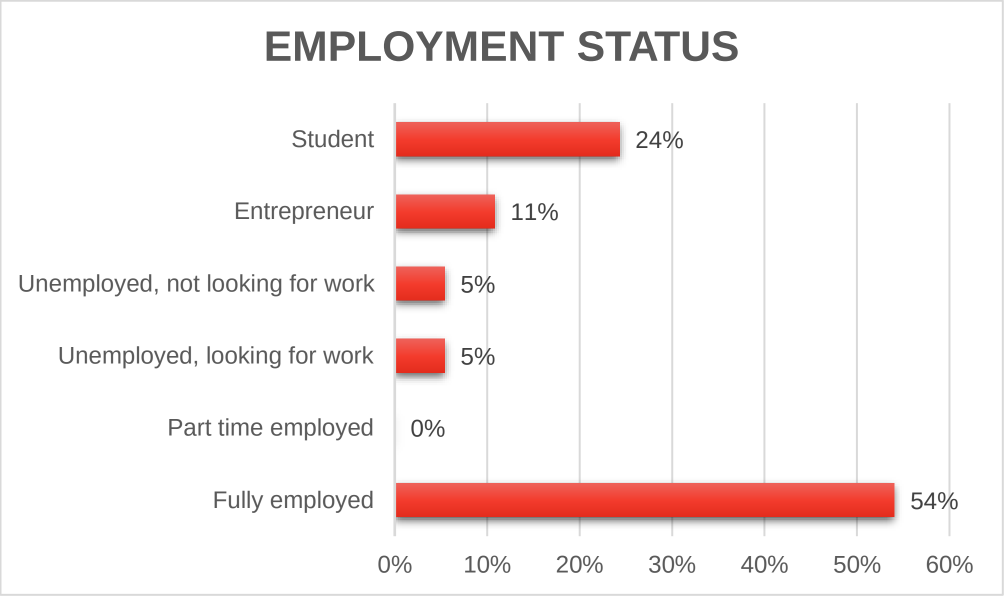
Figure 59. shows the Country of residence of the respondents. The major part of the respondents come from Europe – 76% - 68% of whom are from Italy. Other European members are from Scotland, Latvia and Czech Republic. 5% of respondents are from USA, 5% from Mexico and 5% from Canada, while 3% respectively are from Australia, Russia and India. The provenance should not be considered a reliable data for making considerations. Probably the greatest turnout to fill in the questionnaire by people from Italy has no analytical implications but derives from a greater identification and interest in the research presented within the community as a research conducted within the University of Padua. Members of international communities have probably founded more hesitancy and less identification and affiliation feelings regarding the questionnaire. But a consideration can be made regarding the Italian respondents. **Figure 60.** shows the provenance of respondents in the different parts of Italy: 60% are from North Italy, in particular from Alessandria, Trieste, Torino, Milan, Ancona, Belluno, Monza and Brianza, Modena and Pavia. 32% are answering from Centre Italy, in particular from Terni, Grosseto, Latina, Rome and Frosinone. Only 8% are from South Italy, Naples and Reggio Calabria. The Italian distribution shows an important evidence of a major diffusion of Makers Communities in the northern part of the country, or in any case a greater willingness to collaborate to university researches.

Figure 60. Focus on Italian Respondents Provenance



Source: Own Elaboration, 2019

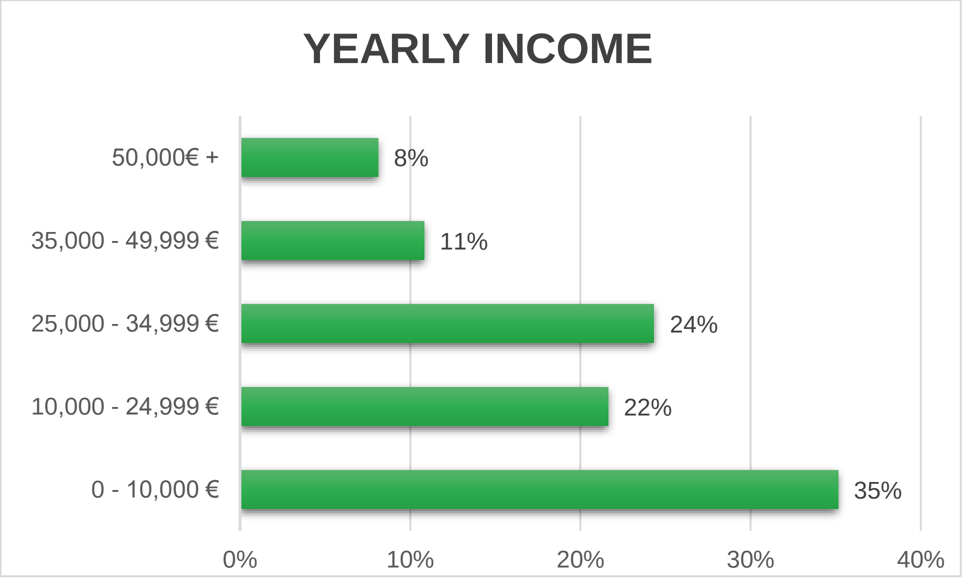
Figure 61. Sample Employment Status



Source: Own Elaboration, 2019

Looking at the Employment Status of the respondents, we see that 54% of them are Fully Employed, followed by 24% of Students and 11% of Entrepreneurs (**Figure 61**.). The remaining part is made up of Unemployed or Retired. Among Workers and Students, it is interesting to understand how many are employed in activities that are related respectively to the Automotive world and to the world of Additive Manufacturing. These specific data will be displayed and commented later in the analysis.

Figure 62. Sample Yearly Income



Source: Own Elaboration, 2019

Finally, a classification of the respondents was made by Yearly Income levels (**Figure 62**.). About 81% of respondents falls into an income bracket of less than € 35,000 per year, with 35% below 10,000.

4.5.3 The Results

In this section of the Fourth Chapter we will focus on the results of the questionnaire, divided by Four Macro Areas: Activity inside the Community; Automotive industry; Additive Manufacturing and 3D printing activity; FabLabs and Makerspaces environments.

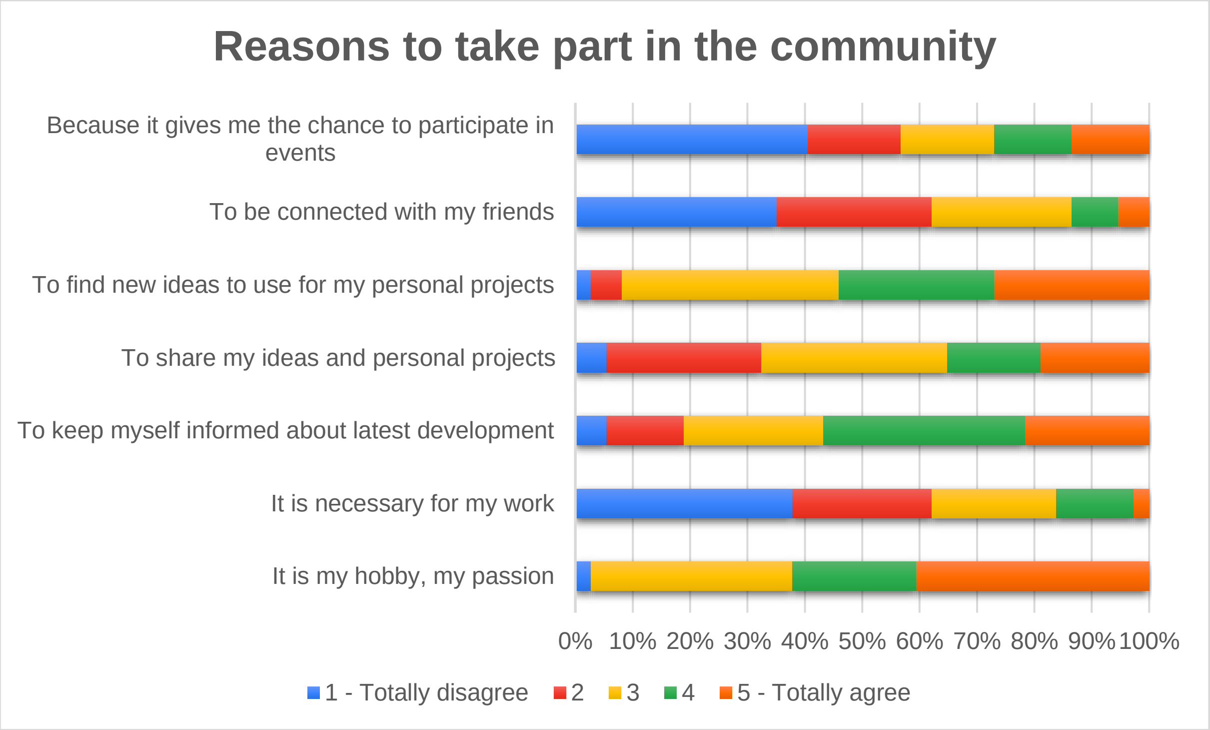
Each respondent belongs to one or more Communities of Makers. In particular, the 30% of them reach the questionnaire through the Stampa 3D Italia Telegram Group, the other 30% from Stampa3DForum, 24% from the Facebook Community 3D Printing Car and Bikes Parts, a further 11% from Hackster and the last 5% from Instructables. The research includes people that are belonging to a community from very different time lapses: around the half of participants are quite new, since they are in the community from less than one year (**Figure 63**.). They are the 51% of respondents, 35% of which are inside the community from less than 6 months. The other half is dealing within the community from more than one year, with a 27% registering a participation from more than 3 years. What can be inferred is that there is an important group of members that are quite loyal to the Community, thus meaning that they took the participation to the Community something very useful and serious. The other observation that we can make is that, at the same time, there is an important part of the respondents that are recently approaching the Community; this means that those groupings are not statics and that more and more people are interested in joining a 3D printing Community to become more familiar with the sector, motivated by their passion or needs.

Figure 63. Members' participation length in the Community

Source: Own Elaboration, 2019

After assessing the membership length, the main goal of this investigation section is to understand the reasons why they take part in the community and their main activity inside the community (**Figure 64**.). The main reason identified for taking part in the community is because "It is my hobby, my passion". In fact, 41% of the respondents totally agree in identifying these reasons as the motive why they participate in the community. More in detail, the 62% of the respondents declare to Agree and Totally Agree, 35% is Neutral and only the 3% Totally Disagree. The second and third main reasons identified are "To keep myself informed about the latest developments" and "To find new ideas to use for my personal projects". They registered respectively 57% and 54% of Totally Agree and Agree answers. The results show that "Sharing personal ideas and projects" is not among the main reasons for people to participate in the community: only the 35% of respondents Totally agrees and Agrees with this choice, while 32% Totally disagree and Disagree, and the 32% remain Neutral. This could be for different reasons: because some people participate in the community to reach other's ideas but it is not able or it has no interest to develop personal projects, or it can be because people are more willing to obtain other's project than to share their own. The last three reasons registered a clearly negative response. One of the last reasons to take part in the community results to be "Because it gives the chance to participate in events". The 57% of respondent answer Totally Disagree and Disagree to this point, and 16% remain Neutral. This can be due to the fact that some of the community are frequented by people coming from different parts of the world or of the country, and their main objective is to collaborate from distance, but they do not have neither interest not possibilities to organize meetings and event where to go together. The other two reasons that registered a more negative response are “It is necessary for my work” and “To be connected with my friends”, with respectively 62% each of negative response, and 22% and 24% of neutral ones. Again, this first query underlines that in most of the cases the additive world is a hobby for the members, and has nothing or little to do with their professional work. The results also show that the community is not shared with personal friends of the members, that may have different passions, but is more an external environment where virtually meet with other hobbyists and share the same interests.

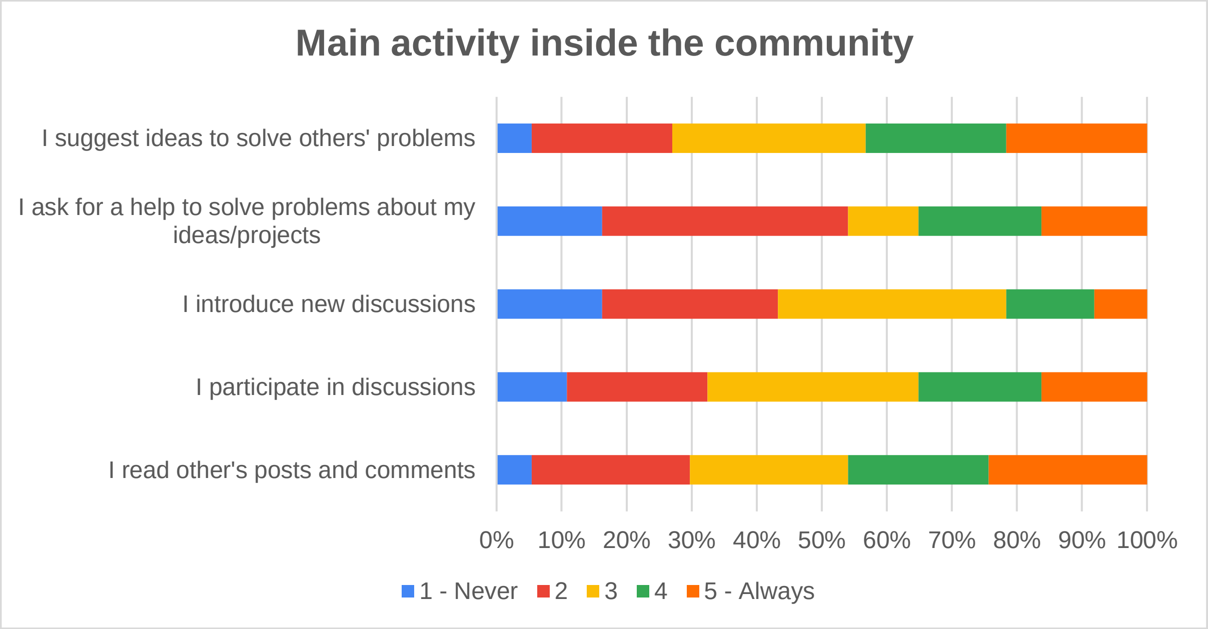
Figure 64. Members’ motives to take part in the Community



Source: Own Elaboration, 2019

The questionnaire also focused on the main activity of members inside the community (**Figure 65**.). The principal activity of members inside the community is to “Read other’s posts and comments”, followed by “Suggest ideas to solve others’ problems”. They respectively registered 70% and 70% of answers going from Sometimes to Always, in particular 46% and 43% Often and Always. They also declared to participate in discussions – 68% of answers Sometimes, Often and Always – and more rarely to introduce new discussions – 35% Sometimes, cumulative 43% Rarely and Never. They even more rarely declared to “Ask for help to solve problems about their ideas and projects” – 54% of them answered they Never or Rarely ask for help inside the community. These results show that the community members are more willing to participate in discussions and help others than asking solutions for their problems. This once again can be because they are not willing to share their projects with the other members of the community or because they do not produce a lot of ideas and projects, but their activity is mainly dedicated to look at what the other members do.

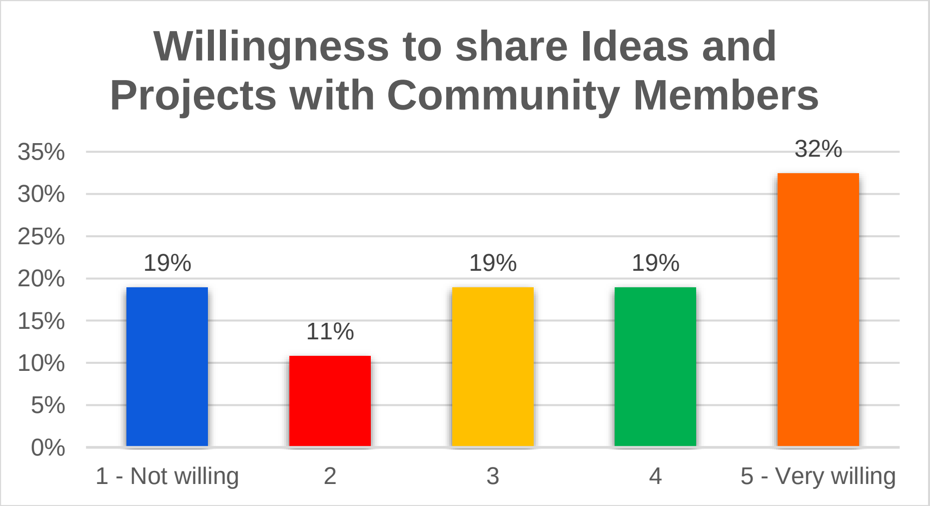
Figure 65. Members' activity inside the Community



Source: Own Elaboration, 2019

At the same time, when is directly asked to them if they are willing to share their own ideas and projects with other community members, the 32% of the respondents' answers that they are Very Willing, and overall the 70% are positively willing to concur in building an open community (**Figure 66**.). This can be the prove that they are potentially willing but de facto they don't share so much inside the community because most of them are not so productive in terms of Additive Manufacturing ideas and Projects. At the same time this result can evidence that there is an incongruence in the questionnaire results and in the ay respondent fell in it.

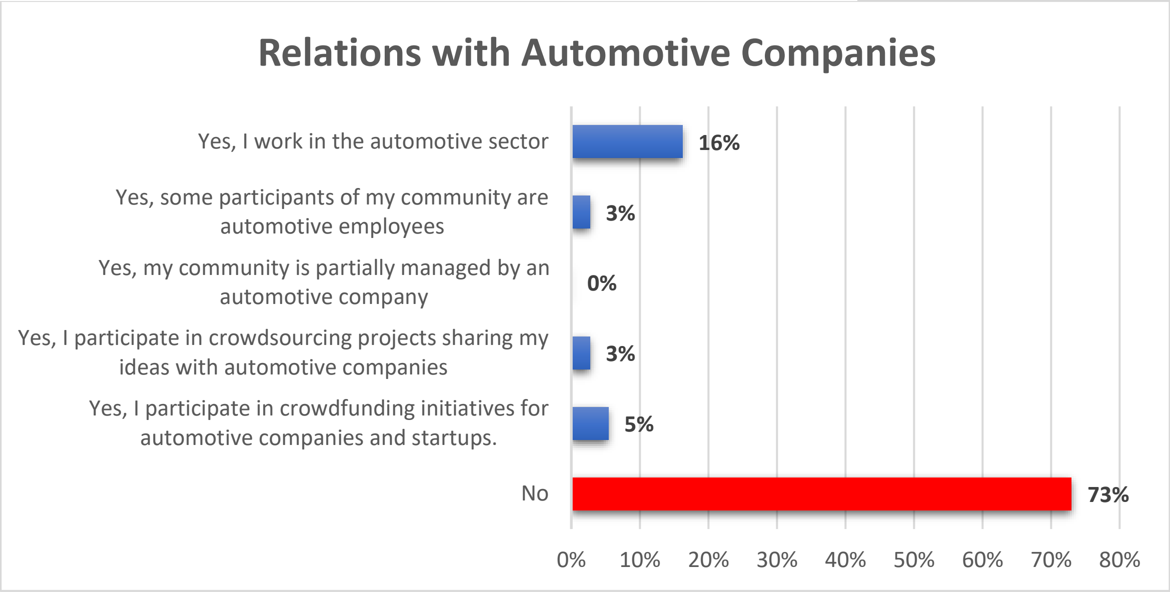
Figure 66. Members' willingness to share Ideas inside the Community



Source: Own Elaboration, 2019

The second part of the questionnaire focuses on analyzing the relationship between the community members and the automotive industry. The first question, in fact, is if community members of the community itself have some kind of relationships with automotive companies (**Figure 67**.). 73% of the respondents answers No, showing that there is still a huge distance between final users and the automotive manufacturers, constituting them a very big and close environment that only in the last years is opening towards customers. 16% of the respondents works in the automotive sector, while only 5 and 3% of the respondents have ever participated respectively in a crowdfunding initiative or a crowdsourcing project within the automotive sector.

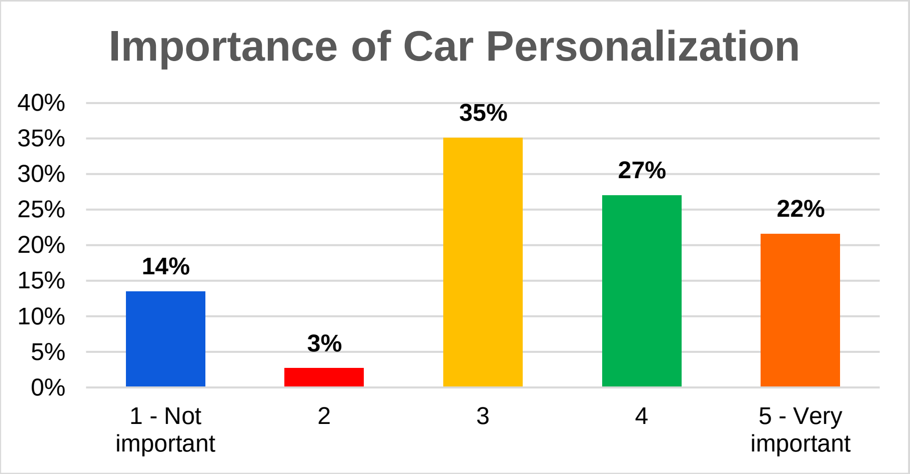
Figure 67. Relation between Communities and Automotive Companies



Source: Own Elaboration, 2019

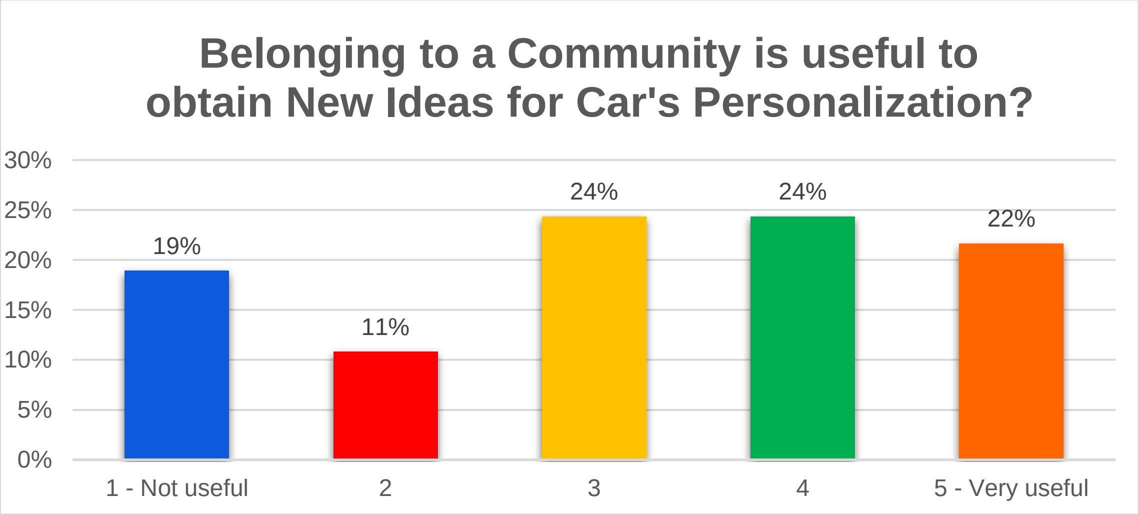
The next two questions are focusing on Car's Personalization. Firstly, we asked the interviewed how much importance they give to their Car's Personalization (**Figure 68**.). For the 35% of the respondents it is Moderately Important, while for nearly the half of them – 49% - it is from Important to Very Important. Only the 17% of the interviewed the personalization has slightly to zero importance. This first data shows that car's personalization that more and more companies – as the ones cited in our case study – are striving to offer, is well appreciated by customers.

Figure 68. Importance of Car Personalization



Source: Own Elaboration, 2019

Figure 69. Connection between Community and Car's Personalization ideas

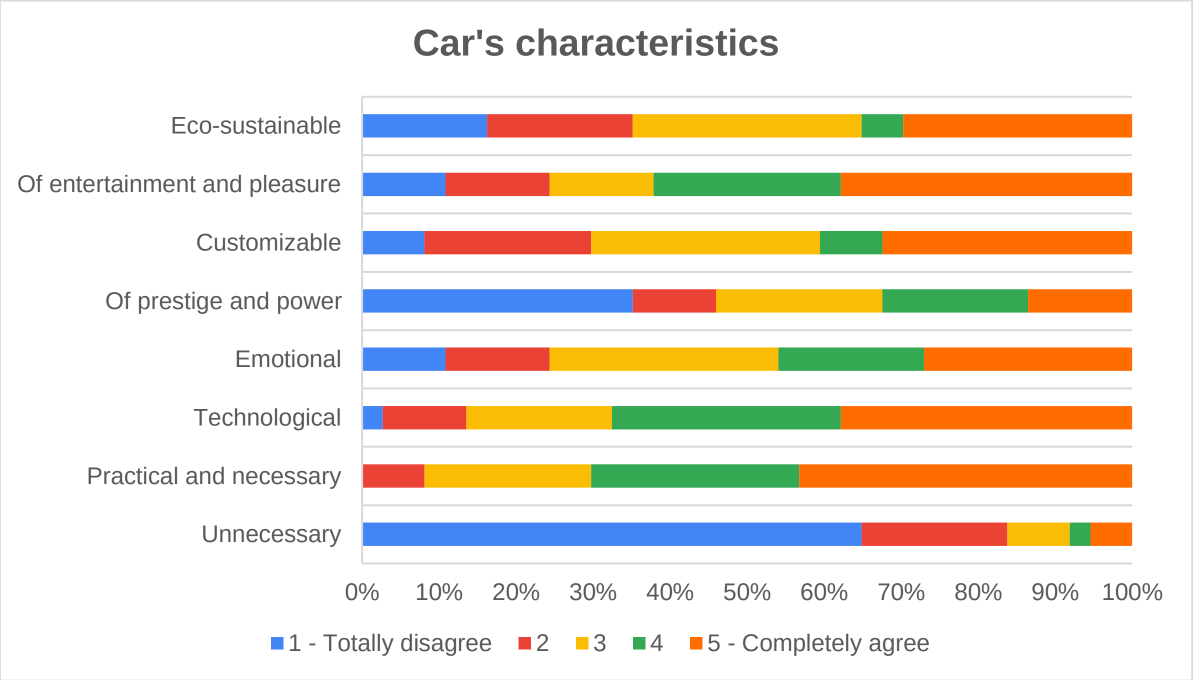


Source: Own Elaboration, 2019

The very next question tries to understand if there is a connection between the Community membership and the Maker activity for the personalization of the Car (**Figure 69.**). 70% of respondents declares that belonging to a community is useful to obtain new customization and personalization ideas for their cars – 22% Very Useful, 24% Useful, 24% Moderately Useful. The remaining part probably have other interests inside the community apart from the automotive sector. The next question aims at defining which importance is given by the community members to the car: it is asked to them "The car is for you something…" (**Figure 70.**). Almost the totality of them – 92% - agrees on refusing the idea that the car is an unnecessary object to possess – from Totally Disagree to Normal. In fact, as litmus test, exactly 92% of them declares that the car is a Practical and necessary object – from Normal to Totally Agree. 68% of the respondents find the car as a technological object – Agree and Strongly

Agree, and at the same time they recognize this instrument as a source of entertainment and pleasure – 62% cumulative Agree and Totally Agree. 46% of them – Agree and Totally Agree – find the car an Emotional object, while 41% find it something Customizable. They do not agree with identifying the car as something that is able to give them prestige and power – 46% Totally Disagree and Disagree, while the 30% of them totally agree on finding a car as an eco-sustainable product. As we can see from these results, the customization of the car is not at the first places for importance. This is probably due to the main functions that a car performs: as it is clear also from the respondents' point of view, the car is primarily a necessary object, especially for those countries or cities where the public transportations are not so developed or diffused.

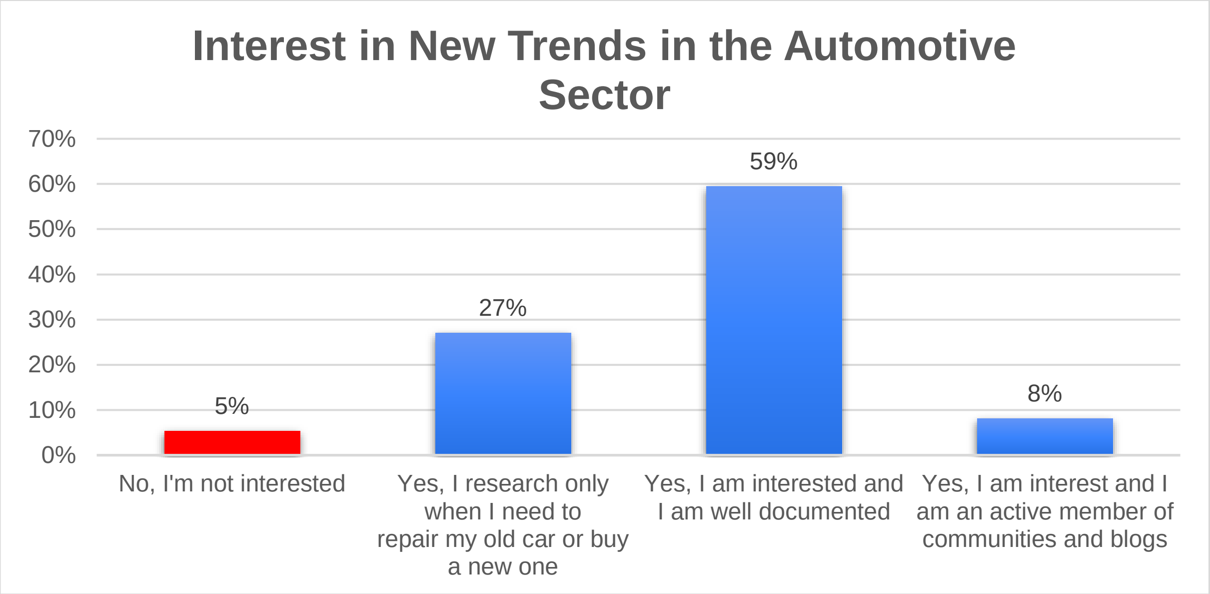
Figure 70. How Members define their Cars' characteristics



Source: Own Elaboration, 2019

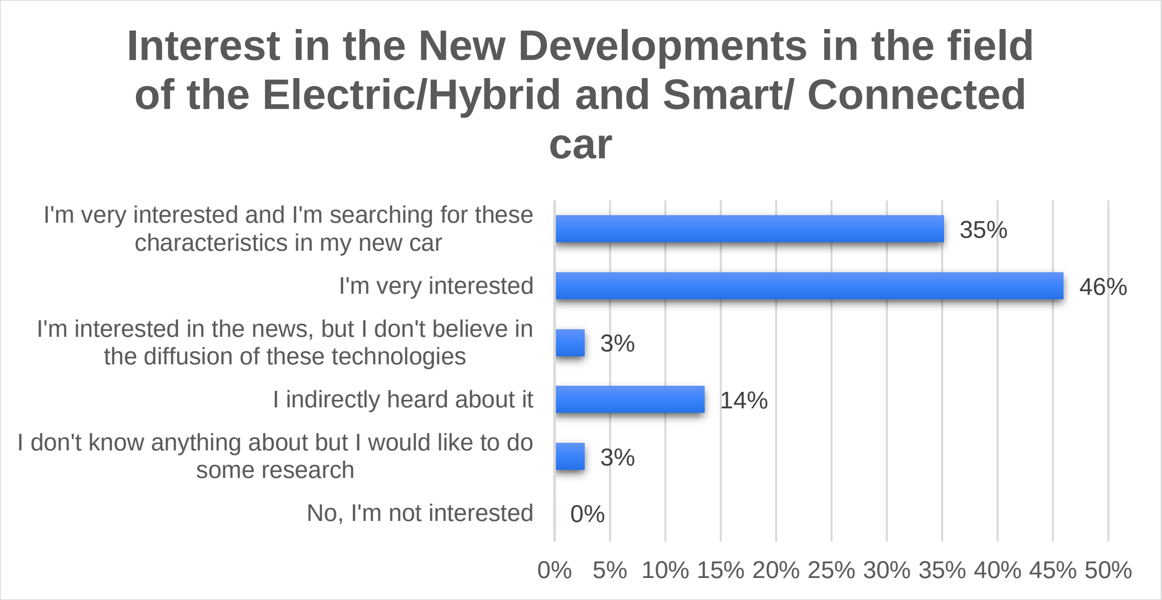
The last two questions are an investigation of the interest in the new automotive trends by members. The first, generic question, ask if they are interested in the new trends in the automotive industry (**Figure 71**.), and 59% of the respondents answered that they are interested and well documented in innovations and new trends and an additional 27% declared to be interested, but only when they need to repair their old car or buy a new one. Only the 5% of them declare to be not interested. The second question goes furthermore in detail, asking if the members are interested in the new developments in the fields of the EVs and the Smart Car (**Figure 72**.). 46% of them results to be very interested and an additional 35% is interested and is willing to search for these characteristics in his new car.

Figure 71. Members' Interest in Automotive New Trends



Source: Own Elaboration, 2019

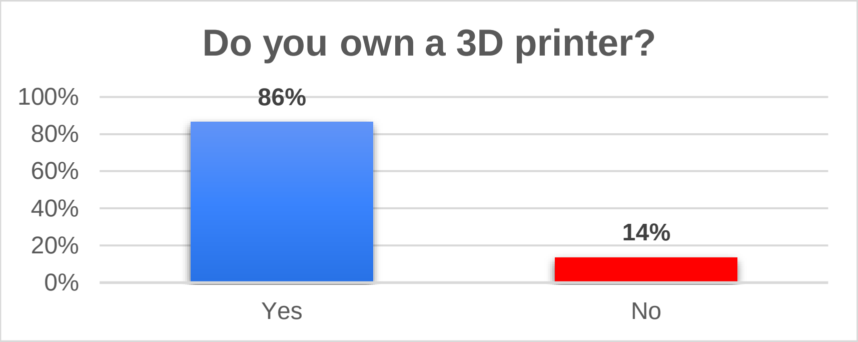
Figure 72. Members' Interest in Electric and Smart Car's Developments



Source: Own Elaboration, 2019

The next and third section is concentrated on the 3D printing activity of the community members. The first question, of course, wants to determine how many members personally own a 3D printer: 86% of them (**Figure 73**.). Only 14% of respondents are not owners of a 3D printer, so it is supposed that they participate in the community discussion activity just as people interested in the field, but not as real Makers.

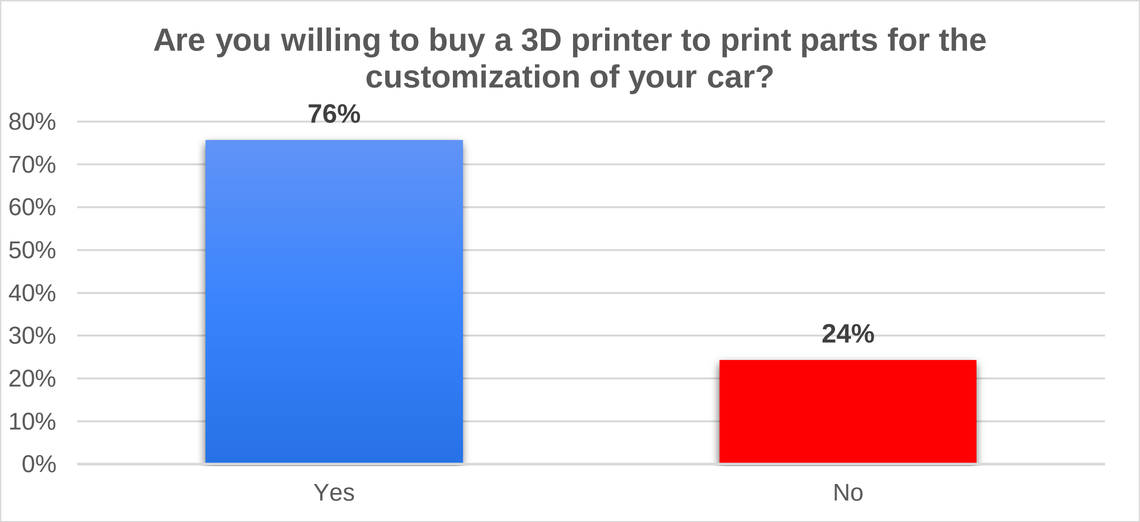
Figure 73. 3D Printer Ownership



Source: Own Elaboration, 2019

The second question regards the printing of automotive components. It is asked if they are willing to buy a 3D printer to print part for the customization of their car (**Figure 74**.): 76% of them answers Yes. Actually, the 32% of them declared that they already use a 3D printer for printing automotive components. What they claim to print for cars covers a wide range of printing materials used and end products made. Some examples are collars for cooling vents, spare parts for repairing the internal/external bodywork, intake manifolds, printed metal components of engines, instrument clusters, pedals, mirror supports, knobs, switch caps, foot pegs, levers, fairing, filter covers and gauge housings. What they mostly agree on finding useful to print directly at home are hard to source auto, motorcycle spare parts and custom parts. These respondents show how 3D printing can become useful in the automotive sector, and how democratization of tools printing, in more and more materials and allowing for more and more details and precision making, is the start of an unseen before revolution.

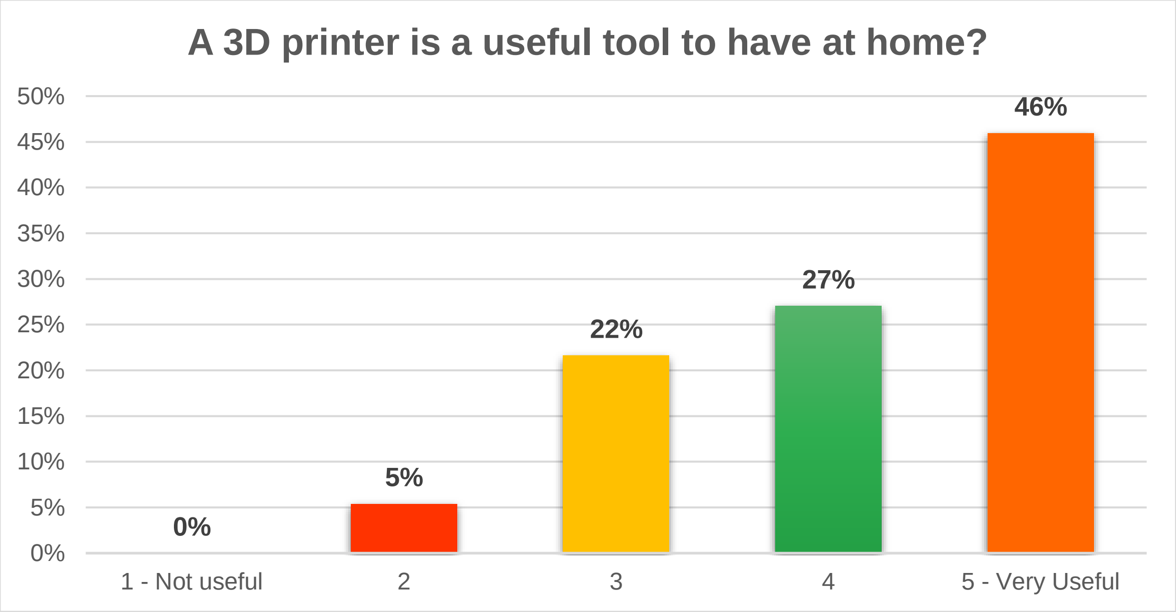
Figure 74. Members willingness to buy a 3D printer for Car's Customization



Source: Own Elaboration, 2019

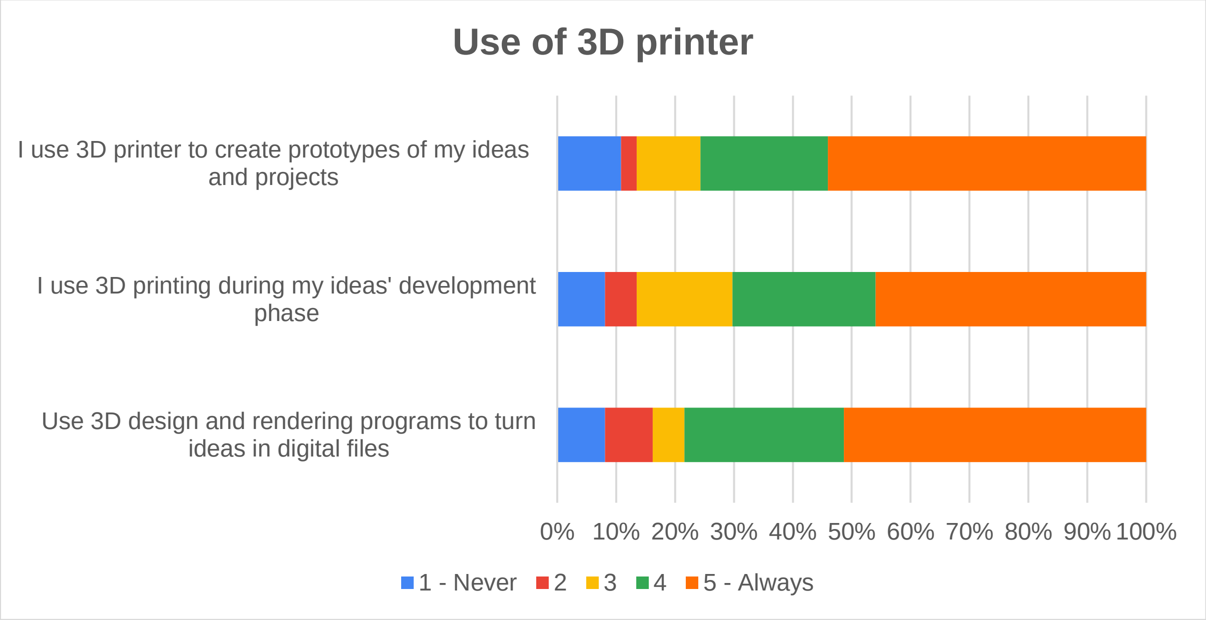
The last part of this section focuses on the usefulness, use, and ease of use of a home 3D printing. It is firstly asked if they think the 3D printer is a useful tool to have at home (**Figure 75**.). 46% of the respondents find the 3D printer very useful, with a further 27% of them finding it Useful and 22% Moderately Useful. Only the 5% of the interviewed neglect the usefulness of a home 3D printer.

Figure 75. 3D Printing Usefulness



Source: Own Elaboration, 2019

Figure 76. 3D Printing Members Utilization



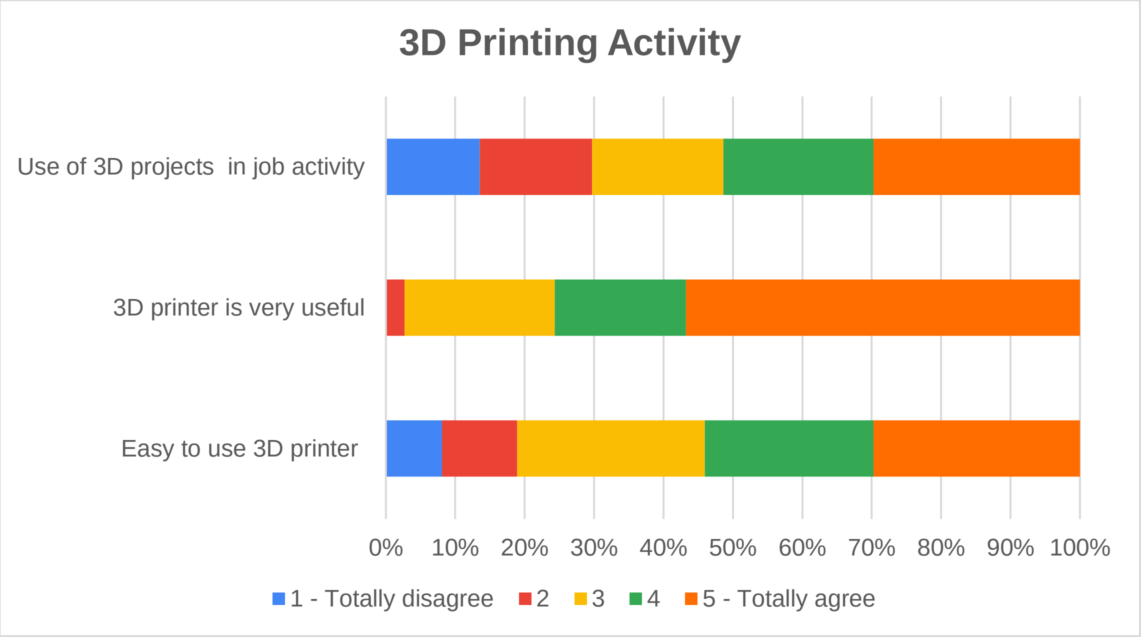
Source: Own Elaboration, 2019

The following question is about the use of 3D printing, and in particular it wants to analyze in which phase of the 3D printing process the users utilize it – ideation phase, development phase and prototype phase (**Figure 76**.). 78% of them Often or Always use 3D printing technologies in the ideation phase, when they turn their ideas in a digital file. 70% of the interviewed use 3DP tools in the development phase, while 76% of them use 3DP to create prototypes of their projects and ideas.

The last question goes more in depth in understanding the activity of the Makers with their 3DPs (**Figure 77**.). One question is nothing more than the same question about usefulness asked before. This question has the only scope to validate the answers given before and testing the attention of the respondents. Even in this case, cumulative the 97% - was 95% before – of the interviewed answered that agrees on finding a 3D printing a very useful tool. The other question regards the easy to use of a 3D printer. 54% of the respondents Agree and Totally Agree on the ease of use of a 3D printer. 27% of them remain Neutral.

The last question is the one related to the connection within the Job Activity and the 3D printing projects. Here the half of the respondents answer that yes, there is a correlation between their Makers' activity and their job. In fact, lots of them are working in completely different sectors, like Education, Building sector, Physics, Gaming, Air Navigation, Transportation, and some retired. Only a few of them are working in the 3D printing sector or related fields. This sections shows how 3DP is reaching broad importance among the hobbyists and people that chose to approach this new technologies, and at the same time it can be not only a passion but it is proved to be a very useful tool even if home-practiced, not only for automotive parts and components but in an infinite range of applications.

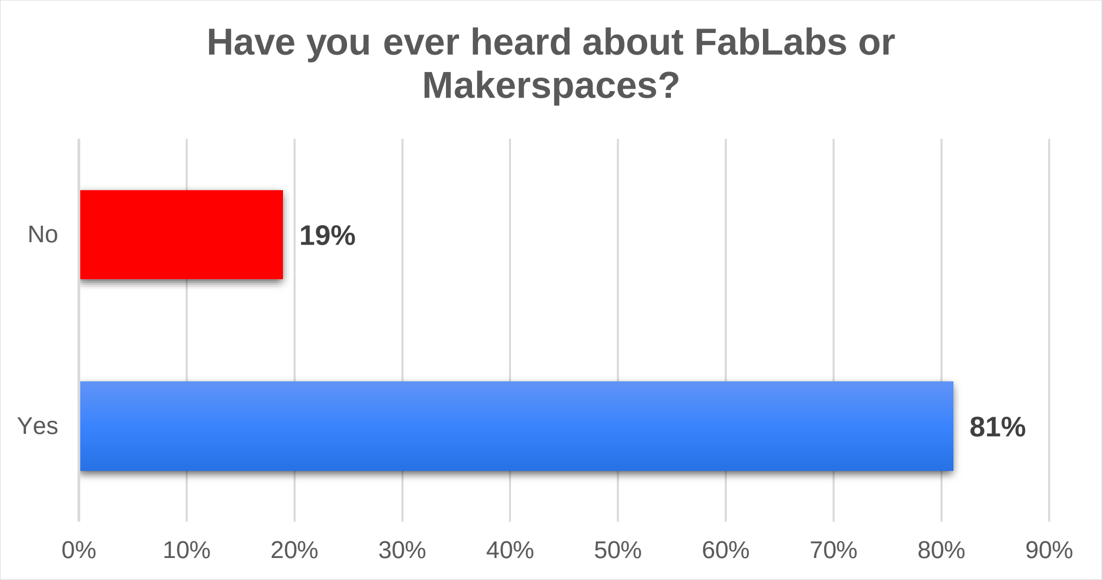
Figure 77. 3D Printing Activity of Members



Source: Own Elaboration, 2019

The last section of the questionnaire is a research about FabLabs and Makerspaces connection with Makers community members. The first question wants to understand if they have ever heard and know something about FabLabs. 81% of respondents answer yes, while only 18% of them declare that they have never heard about the phenomena (**Figure 78**.).

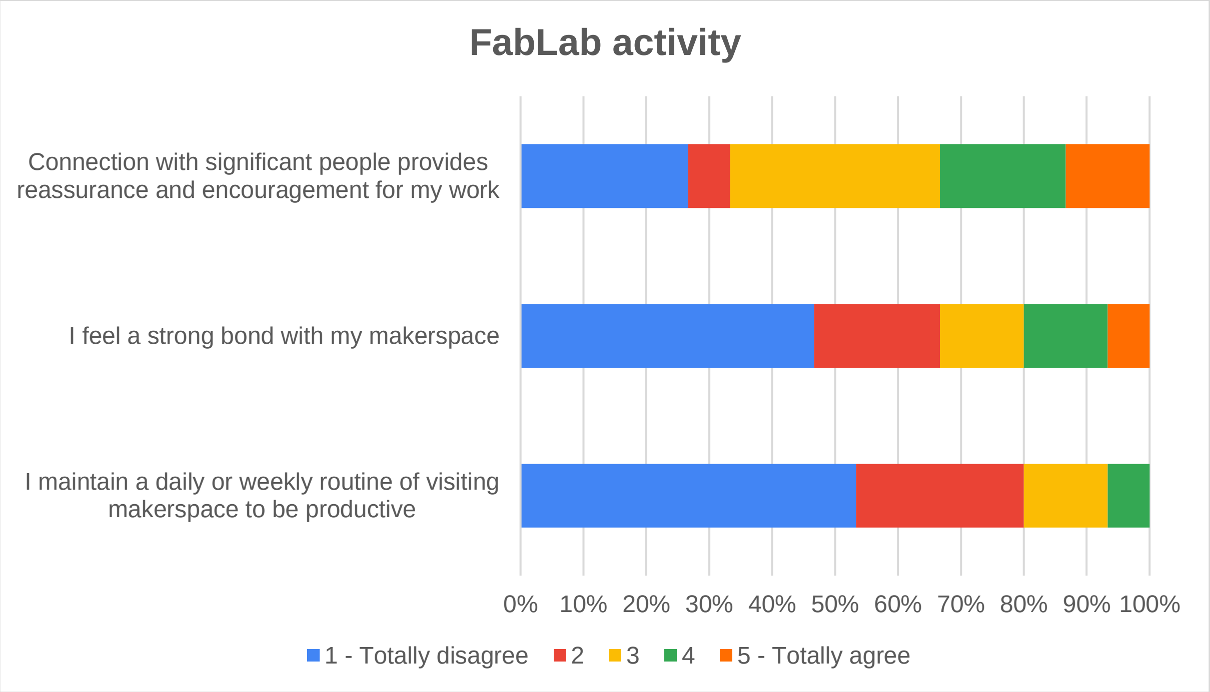
Figure 78. Members familiarity with FabLabs



Source: Own Elaboration, 2019

The second question goes a little more in detail, asking them if they have never been in a FabLab (**Figure 79**.). In this case, the answer is very different from the previous question: the 59% of the respondents declare that they have never been in a FabLab, confirming the hypothesis that they participate mainly in the virtual activity of the community – since they declared to be not interested in events and meeting organized within the community members. 24% of them declared that they rarely go in a FabLab, and only 5% are active members of those physical space aggregations. This question was a barrage question, and all those who answered “No” did not move forward with the next and final question regarding the internal environment of the FabLabs and their relationship with it. As a result, only 15 respondents proceed to the final part of the questionnaire. The major part of them (93%) – as stated in the precedent question - declared that they do not maintain a daily or weekly routine with the Makerspace to be productive. The 80% of them don’t feel a strong bond with the Makerspace, while only the 33% of them feels that FabLabs allows for connection with significant people and give them reassurance and encouragement for their work.

Figure 79. Members connection with FabLabs Environments



Source: Own Elaboration, 2019

This last part shows how, where the 3D printing communities and activities are well diffused and established among participants, the same one does not have a real connection with physical FabLabs. This is maybe due to the fact that virtual aggregation is easiest and costless, or because Makerspaces are not well promoted among Maker Communities. The reasons of this preliminary results should be analyzed more in detail through further investigation.

The main goal of this preliminary analysis was to give a general overview of the phenomena and indicate which are the main possible research topics for further investigations.

4.6 Conclusions

Downstream of the analysis work carried out, with the aim of introducing and analyzing the significant potential brought with the advent of 4.0 technologies, introducing the changes that these innovations have brought within the Manufacturing sector with a specific focus on the Automotive sector, and presenting the Movement of the Makers and all those agglomerations of end users who, thanks to new technologies, have started to make their DIY activities a real starting point for change, we try to complete some final considerations.

From the analysis of documents taken from the literature, some elements emerged that define the importance and the advantages of the adoption of some specific technologies of the industry 4.0, both for the more structured companies and for the single consumer. The democratization of Manufacturing tools such as Additive Manufacturing has allowed the creation of a real little world within people's homes, which creates an answer – that is not always obvious – to the customers' needs not satisfied by the market. Once the advantages and disadvantages of these tools have been identified, it was useful to investigate between companies what the actual propensity of companies to adopt such strategies is.

The goal of the work was to carry out an introductive study in order to evaluate what are the trends in the market in the international context among the largest companies in the automotive sector, in terms of propensity to adopt the latest 4.0 innovations and in terms of implementing business tools to guarantee the customer the best experience in the customization of the final product. From the analysis of the major car manufacturers emerged that different positioning companies that are offering very diversified final products, for different segments of the final market - starting from small cars up to hyper cars - are equally interested in satisfying the new emerging needs of consumers by offering the best technological systems, green and connectivity tools and product customization. It should also be emphasized that this analysis was conducted mainly by relying on secondary sources such as company sites, which in some way can distort information or not be particularly detailed. It is mainly for this reason that this first analysis of the automotive sector was followed by a specific analysis of business cases belonging to the same industry and offering very innovative product by constituting very innovative business models. Business cases show the current situation of companies and their prospects in the Green, Smart, Additive Manufacturing and Product Customization areas. The information was obtained not only through secondary sources but also, and above all, through direct interviews with company representatives.

The exploratory analysis which I carried out continued with the study of the World of Makers, investigating within their Communities, trying to understand the characteristics and internal network of relationships, and their connection with the Automotive and Car Customization world in optics 3D Printing. “Product Customisation is the manufacturing response to consumer individuality.” Considering a customised supply chain, we can assume that the manufacturing process is configured in such a way that input from the consumer can be taken into account during the creation of the product, without incurring in loss of efficiency and flexibility for the production process. Before Industry 4.0, customization was quite a dream, only possible in the very smallest and most artisanal reality, not compatible with the rules of an assembly line production. Today, customisation has progressed beyond footwear and executive cars and is becoming a common addition to the AM and 3D printing supply chain. Companies are enabling customisation by giving access to consumer to a range of design tools with which they can input their requirements into the manufacturing supply chain. Such tools include for example desktop and web-based design interfaces, affordable scanning and reverse engineering hardware, from which they can produce printable data. (Reeves, Mendis, 2015).

The research shows that both for companies and for final customers, Additive Manufacturing is the more flexible, fast and economic way to introduce products personalization in the production process, even in a big and complex industry like the automotive one.

Although some theorists are of the idea that 3D printing has not yet had an impact on the aftermarket and that consumers who are using home 3D printing to produce parts are very much a niche community, the research show that in the last years, 3D printers’ precision and level of details, and the development of new materials to be utilized for the printing, they brought and will further lead to a fast-growing diffusion of the technology. One important issue to be mentioned refers to the concerning regarding intellectual property issues involved in producing sparing parts, because it will be needed to clarify when third parties could be enabled to reproduce spare parts and components using 3D printing. Issue that, until the big automotive companies will not view the phenomena as a threat, will probably be never handled with. Beyond this, we intend to list some limits and future developments regarding the present document, attributable to the very nature of the investigation. In fact, the exploratory study was conducted on a sample of 37 respondents and 3 companies; from this it follows that the results obtained deserve to be expanded and improved in the presence of a larger sample of companies and respondents, thus increasing the accuracy of the results obtained and investigating on a larger scale. An enlargement of the chosen sample would allow for validate the hypotheses put forward regarding the observed behaviours. As for the future research that this work suggests, the results of the analysis themselves show that there are broad issues of investigation to better define the phenomenon. A focus should be made on the materials and the Additive Manufacturing machinery in use, both on the side of companies and on the side of home-hobbyists. Further details could be made by analysing in detail, and through direct interviews within companies, the ways in which the collaborations between the end customer and the company itself occur, and the benefits founded. This analysis set itself the main objective of outlining a current view of the state of things and the benefits provided by companies to consumers and vice versa, through the adoption and dissemination of extremely advanced dialogue, collaboration and production tools. It emerged from the very first pages how the link between consumer and producer becomes ever closer, the market is becoming increasingly consumer-oriented and the connection and exchange of information and data is always easier, faster and more effective.

In conclusion, it is clear that both industrial Additive Manufacturing and consumer 3D printing provide routes to market for products that have been designed by the consumer and that, over time, online software tools and cloud computing will make co-design possible. The potential of 3D printing and other 4.0 technologies such as Robotics and IoT are beginning to show their positive effects more clearly, giving us a glimpse of the opportunities that in a few years could bring even more significant changes to the manufacturing industry and to the whole world.

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Appendix A – BERMAT INTERVIEW - AUTOMOTIVE INDUSTRY 4.0 AND PRODUCT CUSTOMIZATION

Informazioni generali

1. Ragione sociale

BERMAT s.r.l

2. Com’è nata l’idea di Bermat?

La mia idea su Bermat è nata dalla passione che ho avuto sin da bambino, quindi diciamo da quando ho avuto cognizione e consapevolezza del mio essere e quindi da quando avevo 5 anni sostanzialmente. Avevo, ed ho tutt’ora, un amico che aveva il nonno collezionista di auto d’epoca e da lì abbiamo cominciato a mettere fisicamente le mani, facendo dei grossi danni e beccandoci delle grosse arrabbiature del nonno sulle macchine. Li è partito tutto sostanzialmente ecco.

Quindi il telaio è stato sviluppato da lei? Che fasi ha seguito lo sviluppo imprenditoriale della sua idea?

Si, l’ordine è stato questo: da idea sono nati dei disegni, schizzi, che ho sottoposto a miei amici ingegneri che operano nel settore dell’automotive. Questi ingegneri mi hanno detto che l’idea era fattibile, allora sono passato alla brevettazione e poi all’ingegnerizzazione tramite CAD, calcoli strutturali, però fatti da ingegneri.

Quindi diciamo che la fase pratica è avvenuta in una fase successiva, lei ha disegnato l’idea.

Si, esatto.

3. Numero di dipendenti

Adesso siamo in due, sostanzialmente i soci fondatori. La ragione è legata fondamentalmente ai budget della start up e quindi il nostro approccio è quello innanzitutto di (nei primi periodi, come quello in cui siamo) utilizzare un forte approccio in outsourcing. Specie per ReD, che è quello che conta di più e progressivamente internalizzare quelle che sono le risorse fondamentali. Il nostro programma di assunzione va dal 2019 sino al 2021 e sono previsti nel corso di questo tempo circa una decina di assunzioni.

F: **Per lo più ReD?** B: esattamente

4. Attività dell’impresa

Noi siamo iscritti come costruttori di auto perché stiamo sviluppando un brevetto che adesso abbiamo riconosciuto a livello internazionale (nei paesi target) ed è focalizzato sul telaio dell’auto in particolar modo stiamo sviluppando auto sportive (perché quello è il nostro settore) soprattutto le auto sportive personalizzabili a 360°, quindi diciamo l’ambito della inter-customizzazione, anche se customizzazione è più un termine americano che denota più alettoni e robe inutili. Personalizzazione è quello che ci piace di più, è una cosa più strutturale della macchina, cioè per chi vuole può anche montare le cosiddette modanature ma il nostro brevetto e il nostro prodotto permetterà delle personalizzazioni più radicali e quindi poter intervenire anche sulla scelta di componenti della carrozzeria che poi vanno a definire lo stile della macchina e anche le parti meccaniche.

F: **voi vi occupereste dell'assemblaggio, della produzione? Perché insomma costruire una macchina è un meccanismo abbastanza complesso.**

B: Certo, noi come asset avremo, in particolar modo dal punto di vista produttivo, la produzione del telaio (quello diciamo che è il nostro elemento fondamentale). Tutto quello che è componentistica (motore, batteria, freni) invece sono elementi che ci deriveranno dai partner fornitori che avremo nella nostra produzione. In parole povere costruire il telaio nella nostra azienda, dai nostri fornitori arriveranno i pezzi che poi appunto assembleremo nella nostra azienda.

5. Prodotti

F: quindi non c'è una linea di prodotti? Perché ognuno poi può personalizzare il prodotto, giusto?

B: esatto, dopo in base alle prestazioni, ai tipi di componenti che scegli si andrà ad identificare una macchina che magari è più prestazionale e appartiene al segmento delle GT piuttosto che una macchina più semplice come potrebbe essere una barchetta, sostanzialmente. Diciamo che abbiamo un prodotto unico che può essere reso personalizzato.

F: **a partire dal vostro telaio?** B: si, tutto ruota attorno a quello.

6. Localizzazione

Abbiamo sede nel polo della meccatronica di Rovereto. Siamo lì dal 2015, da quando siamo nati sostanzialmente.

7. Mercato di riferimento – Grado di Internazionalizzazione

F: presumo anche all'estero? B: esatto, soprattutto anche all'estero. In Italia non riusciremmo a vivere. In primis sicuramente l'Italia sempre, però non è il nostro mercato strategico, il primo mercato strategico è il mercato europeo e poi diciamo che il nostro prodotto si sposa molto con quei paesi emergenti, quindi asiatici, che hanno molto la parte made in Italy, soprattutto la personalizzazione, e poi anche gli Stati Uniti. Questo è un quadro complessivo, ovviamente il tutto avverrà in maniera progressiva. Comuneremo dall'Europa.

F: **consumatore target?** B: appassionato di auto che vede nell'auto non un mezzo di trasporto ma un oggetto emozionale come un vestito su misura, un accessorio, sia femminile che maschile, che quindi ama anche la sfida, mettersi alla prova perché noi abbiamo anche una connotazione (anche la nostra contaminazione principale) pistaiola, quindi diciamo che le macchine non saranno delle Porsche ma saranno delle macchine volte all'essenza del divertimento e dell'emozione, sia dalla parte meccanica in primis ma poi anche dalla parte estetica. Paragonando a un competitor potremmo paragonarci a Lotus. Produttori anglosassoni sono i nostri competitor.
Cliente sicuramente una persona facoltosa che può permettersi una seconda o terza macchina quindi un professionista, dirigente, un benestante. Non certo uno straricco perché quello appartiene al mercato Ferrari, Lamborghini, Bugatti.

F: **che grado di preparazione si aspetta? Si presuppone che sia un consumatore che ne sappia di auto**

B: tenuto conto che il livello di personalizzazione non sta in mano assoluta al cliente, cioè il cliente non ha una busta della spesa da cui scegliere, c'è l'altro elemento fondamentale su cui stiamo investendo parecchio che è la parte digitale del nostro prodotto che è appunto il configuratore, configuratore che è più evoluto rispetto a quello che siamo abituati a vedere abitualmente, ispirato ai videogiochi dove il cliente può fare un percorso selettivo essendo guidato da una sorta di ingegnere o stilista virtuale. In base alle scelte poi avrà delle esclusioni in un percorso che sarà guidato. Quindi il grado di preparazione non è da ingegnere piuttosto che da pilota professionista ma appassionato. Penso si possa definire un livello medio di conoscenza.

F: **questo configuratore ha già in sé la conoscenza dell'ingegnere o c'è una persona dall'altro lato che dà degli input?** B: ha già la conoscenza degli ingegneri. Quando io parlo di ingegnere virtuale è perché appunto il (non si sentiva) è già stato studiato e tutti gli elementi che sono stati caricati sono già ingegnerizzati. Quindi il cliente quando farà il suo percorso di configurazione avrà già tutti i dati che servono per la configurazione (peso, prestazioni e quant'altro)

F: **quindi percorso guidato perché c'è scelta fino ai limiti dell'ingegneria?** B: Esatto, sennò sarebbe estremamente di nicchia dove penso che neanche l'ingegnere più appassionato dedichi del tempo, si stuferebbe ecco. Noi vorremmo renderlo fruibile anche perché uno degli elementi del nostro prodotto è il divertimento, la godibilità, quello è il mantra che deve seguirci non solo in fase realizzativa ma anche di conduzione delle scelte da parte del cliente. Da casa avendo quelle informazioni che gli servono per fare della scelta in tranquillità.

8. Fonti di vantaggio competitivo per l'azienda

Innanzitutto questo telaio, questo brevetto, che permette appunto di creare un processo realizzativo di auto personalizzate lineare ed economico rispetto a quello che oggi è utilizzato per la stragrande maggioranza dei casi. Sono due fondamentalmente i processi realizzativi di auto personalizzate: quello canonico dei grandi numeri, delle serie, ma che però appunto per le logiche della catena di montaggio andare a tirar fuori dalla catena di montaggio andare a tirar fuori da essa un prodotto che deve essere fatto in nmila esemplari è una cosa estremamente costosa; secondo esempio è il processo tradizionale, artigianale, però anche quello ha delle diseconomie e ha appunto dei costi e dei (limiti?) molto importanti perché la maggior parte oggi di quel processo è caratterizzato dall'acquisto in auto finita, poi da una fase di disassemblaggio (telaio, meccanica) e poi di riassemblaggio e quindi diciamo non è di certo vantaggioso. Il nostro telaio permette di dare una linearità di progetto, di processo e quindi collocarsi nel mezzo di queste due modalità di realizzazione delle auto. Si può estendere questo concetto non solo al telaio ma anche alla carrozzeria e quindi sezionarla in vari sotto elementi in maniera superiore rispetto a quelli che sono oggi tradizionalmente utilizzati per permettere al cliente di scegliere, combinare questi elementi, comunque con dei risultati finali con stile adeguato alla bellezza che deve avere un'auto italiana. Anche qui c'è un profondo studio, abbiamo un centro stile bravo, giovani di Torino, che ci sta seguendo in questo percorso.

F: **range di prezzo dell'auto quando sarà finita?** B: si può ragionare su un prezzo collegato al punto di partenza base, macchina più scarna, range tra 70 e 80 mila € proprio per collocarci nella fascia di mercato di quei costruttori anglosassoni a cui facevo riferimento prima (Lotus). È un traguardo abbastanza ambizioso, dopo va a salire perché le personalizzazioni possono essere infinite e si può arrivare anche a 200 mila / 250 mila tenuto conto del potenziale di acquisto, il livello di personalizzazione che un'auto può avere. No pomelli d'oro ovviamente, però se le vuole gliele facciamo.

F: **quando pensate di partire con la vendita?** B: l'anno prossimo, 2020, ormai siamo agli sgoccioli, siamo nel pieno della fase di progettazione, prototipazione. Parte molto delicata, complicata, perché non abbiamo grossi budget quindi dobbiamo essere bravi e concentrati sempre e quindi il 2020 sarà l'anno finalmente del mercato e dei ricavi.

F: **più o meno nel momento in cui vado sul sito a personalizzare la macchina, quanto ci vorrà per la realizzazione, per avere il prodotto finito?** B: tempi figli di quello che andrà a scegliere il cliente, possiamo ragionare su quanto può essere il tempo di consegna per la scelta di una macchina leggermente modificata e con richieste programmate, visto la macchina di base semplice, ci vorrà 1 mese / 2 dall'ordine partendo da degli assunti del tipo "già in casa abbiamo il telaio fatto", abbiamo a magazzino componenti che ha scelto il cliente, in un paio di mesi potrebbe essere consegnata la macchina. Questo è il nostro punto di forza, vogliamo dare una risposta più rapida rispetto al mondo della personalizzazione di oggi.

9. Investimento R&D (Su totale fatturato)

Per ora tutto ReD. Si può dire che l'investimento è un 90/85 % in ReD.

Industria 4.0

10. L'azienda ha adottato tecnologie dell'Industria 4.0?

Al momento no. Quello che vorremmo utilizzare per la produzione del loro telaio, per incrementare ulteriormente il livello di personalizzazione e micro-modularità, è l'utilizzo del metal additive in rapid-prototyping: stampa 3d metallica e plastica. Per quanto riguarda il telaio non abbiamo ancora applicato questa tecnologia perché è ancora complicato in termini economici e organizzativi. Stiamo partendo utilizzando i metodi di produzione tradizionali, ma il nostro telaio è già pensato per quell'approccio in futuro – almeno tra due anni. Adesso i nostri fornitori partner utilizzano già la stampa 3d per alcuni componenti degli interni, della carrozzeria e del materiale plastico. Le stampanti 3d costituiscono un investimento importante in termini economici, ha un'alta svalutazione, ma riconosciamo che sia una tecnologia che si diffonde in maniera vertiginosa, tutti i nostri partner che lavorano in questo segmento lo fanno già come business principale quindi ci appoggeremo a loro. Forse introdurremo qualche stampante 3d per qualche pezzo marginale, ma per la produzione ad ora questi macchinari costano troppo. Il configuratore non presenta tecnologie 4.0 come Big data perché costerebbe tantissimo, ma sia la parte hardware che software sono pensate per avere sviluppi in ottica 4.0, quindi elementi di autoapprendimento, su comportamenti del cliente sul configuratore, però adesso il software possiede tecnologia tradizionale. Stiamo investendo molto sulla struttura, sulla fruibilità del configuratore.

11. L’azienda ha beneficiato di finanziamenti pubblici a supporto dell’attività innovativa? (Incentivi Calenda per l’Industria 4.0)

La leva su cui si basa il nostro progetto è appunto prendere parte a finanziamenti e contributi non nello specifico all’Industria 4.0 ma ai contributi previsti per il finanziamento alle imprese innovative. Abbiamo la fortuna di essere nella provincia di Trento quindi abbiamo supporto della provincia. Poi abbiamo anche il supporto di Invitalia, un’agenzia che fa capo al ministero dello sviluppo, che mette a disposizione delle Pmi e startup dei finanziamenti agevolati. Noi viviamo di queste cose. A volte la burocrazia dei finanziamenti dello stato ha delle tempistiche che non combaciano con quelle aziendali.

Per quanto riguarda i finanziamenti, CROWDFUNDING

12. Le conoscenze tecnologiche sono codificate in manuali, mansionari, o sono facilmente imitabili da parte dei concorrenti?

Per quanto riguarda il telaio, siamo coperti da brevetto, quindi non è replicabile. Anche se si volesse replicarlo, occorrerebbe un importante studio ingegneristico.

13. Vengono o verranno utilizzati strumenti di robotica per la produzione del telaio?

La prima fase del nostro prodotto sarà concentrata su una realizzazione del telaio in maniera “tradizionale” quindi ci sarà fisicamente un banco di riscontro su cui verranno istallate le componenti metalliche del telaio. Ogni singolo componente sarà tagliato a laser, ovviamente con degli accorgimenti che permettono già di per sé degli incastri e poi ci sarà un esperto saldatore, perché questa è un’arte ancora difficile da produrre in robotica, e da lì si andrà a realizzare il telaio prevalentemente in una fase di artigianalità molto spinta. Poi, quando si incrementerà lo sviluppo e anche i numeri di produzione del telaio, c’è l’intenzione di robotizzare le parti principali, se non tutte (vedremo) delle saldature, delle giunzioni, del telaio stesso. Le tecnologie innovative che verranno applicate, ma questo in uno sviluppo #2 del nostro telaio, saranno quelle del metal additive e quindi della stampa 3d metallica per il telaio, mentre la stampa 3d in plastica la applicheremo sin dalla prima fase per la realizzazione delle componenti di carrozzeria o componenti legate agli interni.

14. Quali sono i vantaggi che riscontrano i vostri fornitori nell’uso della stampante 3d per realizzare i vari componenti?

Il vantaggio sta nel saltare tutta quella fase onerosa e lunga, in termini temporali e realizzativi, che è quella degli stampi. Con la stampante tu puoi inserire il file così come da progetto, dare l’input alla stampante e quella ti crea già di per se il prezzo, quindi, per un tipo di personalizzazione molto spinto come il nostro, che non dico essere just in time, ma deve comunque avere dei tempi molto stretti soprattutto per delle personalizzazioni variegate e variabili questa tecnologia ci permette di accorciare sensibilmente i tempi di risposta, creare pezzi molto più rapidamente e quindi proporli al mercato in maniera più rapida. Ecco, questo è il vantaggio principale.

Inoltre si riscontrano anche vantaggi in termini di costo, legati alla possibilità di eludere la realizzazione ogni volta di uno stampo diverso, ricorrendo semplicemente alla creazione di un file, di certo più economico, che poi verrà stampato in 3D.

15. Ci saranno elementi della smart car/ connected car all'interno delle vostre auto?

Certo, ci saranno elementi di connettività. Quella che sarà sviluppata sarà un tipo di connettività legata non tanto a elementi per uso quotidiano della macchina come siamo abituati a vedere nella maggior parte delle auto di grande serie odierne, ma più legata allo scopo, alla natura intrinseca "pistaiola" della macchina di Bermat, alla guida sportiva, al divertimento. Un esempio di connettività applicata alle nostre macchine potrebbe essere quella di trasmettere in tempo reale sui propri canali social o all'interno di una propria community le performance della macchina su pista, come tempi, velocità, traiettorie. Sottolineo però che questo è uno sviluppo futuro, non ce lo abbiamo pronto adesso, adesso ci stiamo concentrando sul mettere in pratica il nostro brevetto.

Collaborazioni con soggetti esterni

16. Qual è la vostra propensione a collaborare con soggetti esterni all'impresa? Negli ultimi anni ci sono state collaborazioni con soggetti esterni all'impresa? Di che tipo? (Joint Venture, Acquisizioni o cessioni di licenze, Collaborazioni informali)

Outsourcing – per motivi di budget nella filiera. La utilizzeremo anche in futuro, quando saremo più strutturati, perché per noi è molto importante mantenere una rete di fornitori, clienti, stakeholder. (Networking)
Collaborazioni informali – Rapporti Fornitura-cliente per lo più normali rapporti
Collaborazioni con fornitori – partner: Fornitori che credono al progetto, che sono disposti a cedere la fornitura ad un prezzo di costo, come "investimento" sul futuro dell'azienda. Persone a cui piace il progetto e vogliono diventare fornitori a lungo periodo, perché credono nel successo futuro dell'azienda.
Forma particolare che prevedono di mettere in piedi: Work for equity formula, più che altro con professionisti. A breve entrerà nella compagine societaria di Bermat una realtà legata al mondo del Marketing. L'azienda ha in progetto di ridurre le spese in R&D e crescere il Marketing.
Crowdfunding: con Mamacrowd fino a inizio 2018.

17. Che tipologia di soggetti? (Università, Altre imprese, Centri di ricerca,…)

Collaborazioni avviate non ce ne sono. Ci sono state collaborazioni sporadiche e disorganiche. Bermat ha intenzione di coltivare collaborazioni con il mondo universitario. Hanno collaborato con lo IAD grazie allo studio del Centro Stile di Torino – un ragazzo ha fatto anche la tesi sul design e stile della carrozzeria Bermat.

Creatività interna

18. Viene stimolata la creatività interna? L'impresa concede tempo e risorse ai dipendenti per generare idee nuove – propone loro obiettivi creativi e sfidanti?

La creatività è un elemento quotidiano. Quotidianamente deve essere stimolata la creatività in ottica trasversale. Ci sono sempre momenti in cui l'azienda si dedica alla creatività con contaminazione da parte di tutte le aree coinvolte, anche dal semplice operaio che carica i dati contabili dell'azienda, fino al creativo che opera sullo stile della macchina.

FOCUS: Coinvolgimento del consumatore

19. L'azienda valuta il coinvolgimento del consumatore nel processo creativo?

Assolutamente sì, questa è una domanda molto bella: anche il cliente fa parte del successo del prodotto e dell'evoluzione dell'azienda. Già solo il fatto di creare un percorso in cui il cliente è direttamente coinvolto è il primo inizio del coinvolgimento, che poi vuole estendersi anche in altri ambiti. Coinvolgere sempre più il consumatore con sondaggi, test, opinioni, creare una community sono tutti obiettivi di Bermat.

20. L'azienda possiede un blog/community gestito dall'azienda stessa? Esistono comunità di consumatori o social network in cui si parla del proprio prodotto o dell'azienda (indipendenti dall'azienda)?

Blog e tutto ci che serve per avere un contatto diretto col cliente. Noi siamo un segmento di nicchia per cui i clienti non saranno la massa. Sarà comunque difficile, ma non impossibile gestirli. Il nostro cliente è un cliente trascurato dal mercato di oggi, che ha bisogno di determinate risposte che non gli vengono date dall'industria automotive, per cui è un cliente perso. Noi vogliamo creare delle risposte per il cliente in modo da creare un valore aggiunto che ci differenzi agli altri. Facile parlarne, difficile farlo, ma ci stiamo lavorando.

Il nostro esempio/obiettivo è quello di creare una community alla stregua di Harley Davidson, una comunità molto forte, molto sentita, distintiva. Gli Harleysti sono solidi, si riconoscono a miglia, hanno una storia molto lunga, ma noi speriamo di arrivare lì. O comunque tutte quelle piccole aggregazioni non seguite dal mercato di pistaioli, che si organizzano eventi su pista eccetera. Noi vorremmo cercare di raggruppare tutte queste realtà all'interno della nostra community.

21. Gestire comunità di consumatori quali benefici porta, o potrebbe portare all'azienda?

Permette di avere una risposta just in time dal mercato: orientamento dei clienti, trends, richieste. Permette di rimanere sulla lunghezza d'onda dei desideri del cliente.

Fidelizzazione al nostro brand.

22. L'azienda quali strumenti del Web utilizza, per ascoltare l'utente-innovatore, per coinvolgerlo nelle fasi di concept e sviluppo dei nuovi prodotti?

Ora utilizziamo Facebook, con seimila followers, molto dei quali targettizzati, poi abbiamo Instagram che è un po' trascurato ma sarebbe da coltivare, è molto importante per il nostro segmento. Dopo abbiamo il sito web, in fase di rielaborazione, così da renderlo interattivo, anche dal sito si potrà partire col configuratore.

Pensiamo collaborazioni con degli Youtuber che sono molto seguiti sul nostro segmento, come Davide Cironi, Marchettino e Greg Garage. Questi sono i tre più importanti.

Twitter e Linkedin li abbiamo ma non sono canali che danno un riscontro efficace per ciò che cerchiamo noi.

23. **L'azienda, quali indicatori utilizza per selezionare il cliente da inserire nel processo innovativo?**

Noi daremo considerazione a quelle figure che non solo possono dare una mano con le loro idee, eccetera, ma soprattutto che hanno intenzione di acquistare, acquistano, o frequenteranno attivamente la nostra community. Il nostro obiettivo sarà quello di incrementare il numero dei seguaci.

24. **Quali sono i fattori che influenzano il coinvolgimento del consumatore? (Benefici economici, passione, risoluzione di un problema, utilità del prodotto finale, riconoscimento con l’azienda…)**

Il nostro consumatore ideale è motivato da:
Una macchina esteticamente accattivante, divertente, da utilizzare in pista.
Una macchina bella e che diverte guidando.
Una macchina che è personalizzabile e permette di potersela creare da sé. Da emozione.
Noi cercheremo sempre di mantenere un buon rapporto qualità-prezzo, perché è fondamentale per questo tipo di prodotto.

25. **Benefici per l’azienda che derivano dal coinvolgimento del consumatore? (efficienza, varietà, risposta rapida dal mercato, time-to-market, risoluzione di problemi)**

Il nostro cliente acquista l’auto perché è una sua passione, un oggetto emozionale. Questo permette anche di alzare un po’ il markup, soprattutto all’aumento della personalizzazione, perché per il cliente è più importante il prodotto del prezzo in sé.

26. **Esiste un’unità formale che si occupa delle relazioni con i consumatori?**

Esisterà un community manager.

27. **L' azienda utilizza strumenti di analisi del comportamento del cliente?**

Utilizzerà. Gli strumenti principali saranno quelli offerti dal web e anche eventi e partecipazioni per la nostra nicchia di mercato.

28. **Ha mai immaginato una community di consumatori di cui facciano parte anche persone che possiedono a casa stampanti 3D con le quali possono creare/stampare delle componenti personalizzabili per la vostra auto? Potreste fornire i file di alcune componenti personalizzabili direttamente ai vostri consumatori che poi stamperebbero i pezzi nella loro stanza?**

È un qualcosa che secondo me potrebbe avvenire nel futuro, rientra nella filosofia di personalizzazione di Bermat, avendo noi i file che mettiamo in produzione con i nostri partner, sarebbe ancora più bello immaginare un futuro in cui è il cliente stesso a comprare da noi il file da stampare per potersi personalizzare a casa la macchina. Ì0

Appendix B – RIMAC INTERVIEW – AUTOMOTIVE INDUSTRY 4.0 AND PRODUCT CUSTOMIZATION

1. **How much do you invest in R&D on the total turnover (%)? Your turnover? (last 4 years)**

   We can't give an exact answer to this question, our investments are mainly into R&D but not from revenue but from gathered investments.

2. **Can you explain the process of Product Customisation with your customers? What can customers personalize in your car? How deep is the collaboration with customers?**

   Since Concept_One was made in only 8 units, it was completely bespoke. Customer could fully personalize their car, from the combinations of exterior colors, amount of visible carbon on the body of the car to the materials and colors of the interior. Concept_One customers spent time with Rimac Design team and worked closely together to find the combination that was perfectly matched for them. For some customers we even made possible to be involved in the manufacturing process of decorative carbon fibre parts of their car.

   For the C_Two a number of predefined combinations of exterior and interior will be offered, but the customer will also be able to completely personalize the car to their wishes. A customer will use a very detailed and realistic car configurator program to personalize the car.

3. **Has the company adopted Industry 4.0 technologies? If yes, what are the benefits of Industry 4.0 tools?**

   Rimac is currently transforming from a small volume manufacturer to producing large quantities of high performance electric vehicle components. At the moment, most of manufacturing is not automated but this will change as we are moving to larger quantities. We are using CNC machines and 3D printers in machining parts for our components and cars. This enables us to desing and manufacture almost all parts by ourselves, and in short time periods.

4. **Do Industry 4.0 tools like 3D printing or robotics facilitate Product Customisation?**

   We are using 3D printers in product prototyping. Since we are very vertically integrated company it enables us to change the engineering design of a part of a component and to almost immediately be able to manufacture and test that change.

5. **Does the company look for the involvement of the consumer in the creative process? If yes, what are the benefits for the company from consumer involvement?**

   We are always open to suggestions from our customers, and are happy to hear their ideas and propositions. Close communication with our clients enables us to develop a product which will be best suited to their wishes.

6. **Do you have a Rimac social online community where your customers can interact and that allows you to receive quick information about customers' expectations, problems, new product development ideas?**

   Since hypercars are not mass market products, customer base is very narrow, and we are using alternative communication channels to reach our potential customers and receive information from them.

7. **Rimac C_Two has elements of the smart/connected car like virtual reality tools, driving assistant systems and other connectivity or smart tools like these?**

   Rimac C_Two will have autonomous driving capabilities which will be used for one of the driving modes of the car: “Driving Coach”. The C_Two can load selected racetracks into its on-board systems via the ‘Driving Coach’ function, offering clear and precise guidance on racing lines, braking/acceleration points and steering inputs. A virtual driving coach with a very practical application and learning experience. C_Two will have M2M communication capabilities, and will produce 6TB of data per one hour of driving. That data will be stored in our cloud storage for detailed analysis.

Appendix C – XEV INTERVIEW – AUTOMOTIVE INDUSTRY 4.0 AND PRODUCT CUSTOMIZATION

1. **How did the idea of your start-up come about? Did you already start the production/sale?**

   Our idea of using additive manufacturing to disrupt the conventional automotive production came from many years of working in the automotive industry. Each person in our founding team has at least 10+ years of experience in large automotive OEM in Europe, Asia and USA. Our project is currently in product development stage and we plan to start production in the middle of 2020.

2. **What is your target market?**

   Our YOYO car is an urban electric vehicle for personal, company fleet and car-sharing use. Our main target markets are Europe and Asia, in areas that require innovative electric urban mobility.

3. **Can you explain the process of Product Customisation with your customers? What can customers personalize in your car? How deep is the collaboration with customers?**

   Additive manufacturing (3D printing) allows us to customize exterior and interior plastic parts based on customer’s requirements. With additive manufacturing there is no need for expensive production tools that require 3-6 month to produce. We can do straight from 3D data development to production saving time and money required for tooling. We will have deep collaboration with business customers that require specific designs and features. In the future we plan to expand our design collaboration to individual customers through large design database.

4. **Has the company adopted Industry 4.0 technologies? If yes, what are the benefits of Industry 4.0 tools?**

   Additive manufacturing (3D printing) is one of the key areas of the Industry 4.0. Additive manufacturing allows us to reduce waste, reduce time and greatly cut investment costs. It also gives us great flexibility of design. We are also working on other Industry 4.0 tools such as robotic post-processing and artificial intelligence.

5. **Do Industry 4.0 tools like 3D printing or robotics facilitate Product Customisation?**

   Yes, as previously stated.

6. **Does the company look for the involvement of the consumer in the creative process? If yes, what are the benefits for the company from consumer involvement?**

We work closely with our partners to create vehicles that fit their specific requirements. The benefit to our customers is great flexibility of design and unmatched customer service.

7. **Do you have a social online community where your customers can interact and that allows you to receive quick information about customers' expectations, problems, new product development ideas, ...?**

   At the moment XEV is active on Facebook, Linkedin, Instagram as well as directly through our website. In the future we plan to unveil a more direct online customer community platform.

8. **Does your car have elements of the smart/connected car like virtual reality tools, driving assistant systems and other connectivity or smart tools?**

   Our YOYO car will have internet and GPS connectivity. We plan to introduce smart navigation tools in car sharing vehicles in certain cities in order to enhance city tourism experience. The car has very flexible platform so in the future we will also introduce other smart driving tools and features.

Appendix D – COMMUNITY QUESTIONNAIRE

This questionnaire has the purpose to analyze the automotive community connection with Makerspaces and the utilization of 3D printing solutions.

Demographic information

This section consists of some questions about general information like demographic data.

1. Gender

-M -F

2. Age

- Under 18
- 18-24
- 25-34
- 35-44
- 45-54
- 55-64
- 65+

3. Education

- Primary school
- Higher School
- College
- Bachelor
- Master
- PhD

4. City and Country of Residence

5. Employment status

- Fully employed
- Part time employed
- Unemployed, looking for work
- Unemployed, not looking for work
- Entrepreneur
- Student

6. Profession and working sector

7. Yearly Income

- 0 - 10,000 €
- 10,000 - 24,999 €
- 25,000 - 34,999 €
- 35,000 - 49,999 €
- 50,000 €

Community activity

This section focuses on your activity inside the community

8. Name the community where you found this questionnaire *

9. How long have you been member of this community

- 0-6 months
- 6-12 months
- 1-3 years
- 3+ years

10. Are you a member of other communities?

- Yes - No

11. If yes, can you name some?

12. What are the reasons why you take part of this community? (Likert: 1-Totally Disagree; 5-Totally Agree)

- It is my hobby, my passion
- It is necessary for my work
- To keep myself informed about latest development
- To share my ideas and personal projects
- To find new ideas to use for my personal projects
- To be connected with my friends
- Because it gives me chance to participate in events

13. What is your main activity inside the community? (Likert: 1-Never; 5-Always)

- I read other's posts and comments
- I participate in discussions
- I introduce new discussions
- I ask for a help to solve problems for my ideas/projects
- I suggest ideas to solve others' problems

14. Do you or your community have relations with automotive companies?

- No
- Yes, I participate in crowdfunding initiatives for automotive companies and startups.
- Yes, I participate in crowdsourcing projects sharing my ideas with automotive companies
- Yes, my community is partially managed by an automotive company
- Yes, some participants of my community are automotive employees
- Yes, I work in the automotive sector

15. The personalization of my car is very important

1 -Totally disagree 2 3 4 5 -Totally agree

16. Belonging to a community is very useful to obtain new ideas for my car's personalization

1 - Totally disagree 2 3 4 5 - Totally agree

17. I am willing to share my Autotuning ideas and projects with other community members

1 - Totally disagree 2 3 4 5 - Totally agree

Automotive sector

This section focuses on new trends in the automotive sector.

18. Are you interested in new trends in the automotive sector?

- No, I'm not interested
- Yes, I research only when I need to repair my old car or buy a new one
- Yes, I am interested, and I am well documented
- Yes, I am interest and I am an active member of communities and blogs

19. Are you interested in the new developments in the field of the electric/hybrid and smart/connected car?

- No, I'm not interested
- I don’t' know anything about but I would like to do some research
- I indirectly heard about it
- I'm interested in the news, but I don't believe in the diffusion of this technologies
- I'm very interested
- I'm very interested and I'm searching for this characteristic in my new car

20. The car is for you something (Likert: 1 - Totally disagree; 5 – Completely Agree)

- Unnecessary
- Practical and necessary
- Technological
- Emotional
- Of prestige and power
- Customizable
- Of entertainment and pleasure
- Eco-sustainable

3D printing

This section wants to analyze the relation between community members and the use of 3D printing technology.

21. Do you own/use a 3D printer?

- No - Yes

22. Are you willing to buy a 3D printer to print parts for the customization of your car?

- No - Yes

23. A 3D printer is a useful tool to have at home

1 - Totally disagree 2 3 4 5 - Totally agree

Use of 3D printer

This section is a focus on the use of 3D printing technology

24. I use 3D design and rendering programs to turn my ideas in digital files

1 – Never 2 3 4 5 - Always

25. I use 3D printing during my ideas' development phase

1 – Never 2 3 4 5 - Always

26. I use 3D printer to create prototypes of my ideas and projects

1 – Never 2 3 4 5 - Always

27. I find easy to use a 3D printer

1 - Totally disagree 2 3 4 5 - Totally agree

28. Using a 3D printer is very useful for me

1 - Totally disagree 2 3 4 5 - Totally agree

29. I can use my 3D projects also in my job activity

1 - Totally disagree 2 3 4 5 - Totally agree

30. Which automotive components you print with your 3D printer?

FabLabs and Makerspaces

This section focuses on the relationship between Automotive communities and Fab Labs

31. Have you ever heard about FabLabs or Makerspaces?

- No - Yes

32. Do you know if there are any FabLabs in your city or neighbourhood? Can you name them?

33. Have you ever been in a FabLab?

- No, never (Go to question 39)
- Yes, rarely (Go to question 34)
- Yes, I go there sometimes (Go to question 34)
- Yes, I go there quite often (Go to question 34)
- Yes, I'm an active member of a FabLab (Go to question 34)

FabLabs environment

This section focuses of the behaviour of community members that use to spend time in FabLabs

34. I maintain a daily or weekly routine of visiting makerspace to be productive

1 - Totally disagree 2 3 4 5 - Totally agree

35. I feel a strong bond with my makerspace

1 - Totally disagree 2 3 4 5 - Totally agree

36. Connection with significant people provides reassurance and encouragement for my work

1 - Totally disagree 2 3 4 5 - Totally agree

37. I have a broader sense of purpose of my work

1 - Totally disagree 2 3 4 5 - Totally agree

Makers activities and Occupation relatedness

38. To what extent, your occupation and tinkering activities are related to one another

1 - Extremely not related 2 3 4 5 - Extremely related

End of the questionnaire

This is the end of the questionnaire. Thank you for your collaboration. If you have any question or doubt, please leave your email.