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"THE LATEST AGE OF MASS CUSTOMIZATION: IMPROVEMENTS OF INDUSTRY 4.0"

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Ai miei genitori e a mia sorella per avermi sempre sostenuto durante questo percorso di studi triennale.

Index

Abstract

L'evoluzione delle preferenze dei consumatori ha costituito un punto di criticità per le aziende, le quali si sono trovate negli ultimi anni a dover ricondurre la produzione alle preferenze come mai fatto prima. Alla base della mass customization moderna si trovano pertanto le attività di forecasting della domanda e di analisi dei dati provenienti direttamente dai clienti. L'Industria 4.0 ha ancora una volta implementato le possibilità per far ciò grazie a nuovi strumenti che interessano tutti gli ambiti aziendali, dalla produzione alle relazioni col cliente finale, passando per la logistica e la ricerca e sviluppo. La rivoluzione riguarda quindi l'azienda nel suo complesso e può originarsi a partire dai partners nella catena dal valore o dall'azienda stessa.

Il primo capitolo di questa prova finale verterà pertanto sulla breve trattazione delle rivoluzioni industriali che si sono susseguite, sul significato di Industria 4.0, con un focus costante sulla situazione italiana, sui mutamenti della domanda e sul come con la mass customization le aziende abbiano risposto a questi.

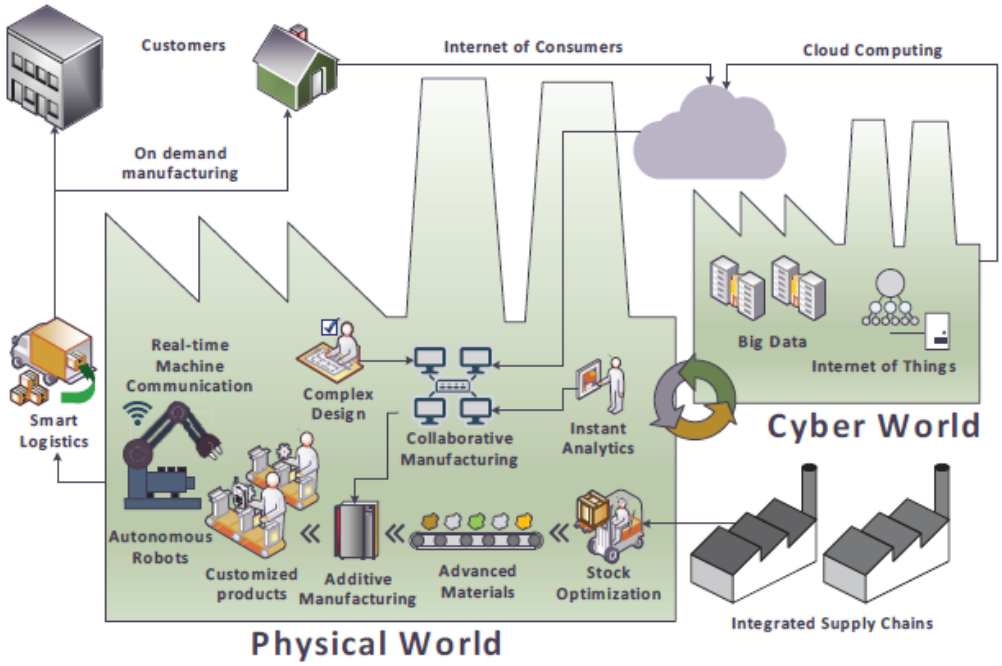
Il secondo capitolo andrà ad investigare più a fondo le tecnologie che sono venute in aiuto alle aziende per creare una mass customization sempre più puntuale, analizzandone nello specifico alcune e la loro diffusione nel tessuto imprenditoriale italiano, portando degli esempi concreti per la comprensione del lettore, dal web alle tecnologie nello specifico.

Il terzo ed ultimo capitolo tratterà l'analisi del caso dell'azienda padovana *O bag*, la quale si è affermata per la creazione di borse ed accessori di moda contraddistinti da un design made in Italy, applicando alla perfezione la mass customization nell'era dell'Industria 4.0.

Chapter 1- Technologies' evolution in meeting customers' requirements

1.1 From Industry 1.0 to Industry 4.0: an ample variety of applications

Several revolutions, by means of disruptive leaps, have changed the way of manufacturing within firms over the centuries. During the last decades of the eighteenth century, *Industry 1.0* brought a revolution in relation to the use of energy: the invention of the steam engine allowed factories to leave behind mills and introduce mechanization of operations with the ultimate purpose of greater speed and power and enabled a significant productivity leap. Around the end of the nineteenth century, *Industry 2.0*, thanks to the spread of electricity in manufacturing operations, made it possible to further increase levels of mechanization in the production. It is thanks to this revolution that, in manufacturing centres, the assembly work line becomes gradually established, inaugurating the mass production era, putting together large volume of exactly alike products at low unitary cost (Langlois & Robertson, 1989). In the seventies of the twentieth century, with *Industry 3.0*, the first generation of ICT appears within factories: by so doing, the level of automation further increases. Nowadays, the so-called *Industry 4.0* is disrupting once again the way of making business as it is combining the use of many new technologies. On 21st September 2016, Federmeccanica published a study called "Industria 4.0" in which 11 *enabling* technologies are identified: mechatronics, robotics, collaborative robotics, internet of things, big data, cloud computing, cybersecurity, 3D printing, simulation, nanotechnologies, and smart materials. Because of the diffusion of the aforementioned technologies, the supply chain is turning into a brand new one, mutating towards a more integrated system. The "smart factory" is now a reality: it includes objects connected between each other and also networked within suppliers and customers, and generally with the external world. The aim of the "new" manufacturing of Industry 4.0 is to make the coexistence of two regularly distinct aspects possible, namely the high intensity of scale economies and the customization required by consumers, through the transformation of the entire industrial production thanks to the merging of Internet and information & communication technologies (ICT) with traditional manufacturing processes (Davies, 2015). Through the mentioned technological innovations, the factory 4.0 is therefore transformed, assuming a new structure. Here is how a typical 4.0 enterprise looks like, in the image below.



Source: Dilberoglu, U. M., Gharehpapagh, B., Yaman, U., & Dolen, M. (2017) *The Role of Additive Manufacturing in the Era of Industry 4.0*, Procedia Manufacturing, 11(June), 546.

It is clear that the integration of the various systems makes the company smart and allows it to interface with the value and supply chain in a completely new way. The term *Industry 4.0* itself has originated from the European Industry 4.0 initiative, inspired by a project from the German government. Specifically, Henning Kagermann, Wolf-Dieter Lukas and Wolfgang Wahlster used the term for the first time in 2011 at the Hannover Fair, when they announced the *Zukunftsprojekt Industrie 4.0*. Implemented at the end of 2013, the project involved investing in R&D to modernize the German production system and bring German manufacturing back to the world's top level, making it globally competitive once again.

1.2 Brief overview of the Italian situation: "*Piano Nazionale Impresa 4.0*".

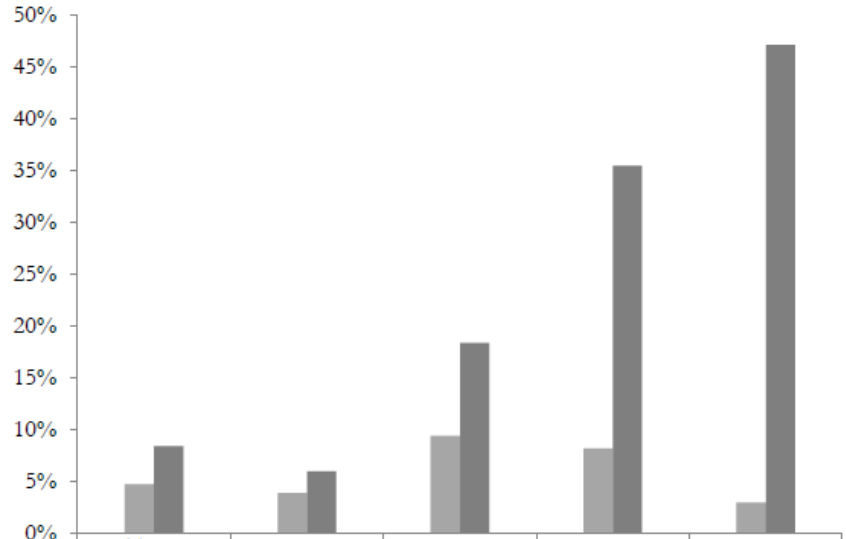
National Business 4.0 Plan *(Piano Nazionale Impresa 4.0)* is government's set of measures and facilities that aim to encourage investments for innovation and the competitiveness of businesses, an aid for all companies which want to seize the opportunities linked to the fourth industrial revolution. The term *Impresa 4.0* has replaced, since 2018, *Industria 4.0* (initially presented in the 2017 Stability Law), representing the choice of the Government to extend the plan also to the services sector, acknowledging a high digitization potential. The vision of *Impresa 4.0* action is that industrial production is no longer just a sequence of separate steps and phases, but its processes are inextricably linked to digital. The connection between objects through the internet, ensured today by smaller and more performing sensors and actuators (e.g.

devices capable of connecting the digital component with the mechanical one), also leads manufacturing industries to be increasingly involved in service activities as the borderline between manufacturing and services becomes less clear every day. These whole measures sets are driven by the awareness that Italy needs to recover a gap in innovation, in "smart" products and technologies development compared to the more advanced countries of the UE, with the ambitious goal of re-launching the *Made in Italy*.

The plan is articulated in 4 strategic directions:

- *Innovative investments:* to grow private investment in the development of enabling technologies and increase expenses in research, development, and innovation.
- *Enabling infrastructures:* to ensure adequate network infrastructures, data security, and protection.
- *Skills and Research:* to create skills and stimulate research through ad hoc training courses
- *Awareness and Governance:* to spread the knowledge, the potential and the applications of the I4.0 technologies and guarantee public-private governance for the attainment of the prefixed objectives

The report of The Ministry of Economic Development underlines that the diffusion of "enterprises 4.0" has achieved 8,4% national average in 2017, with almost 5% of traditionally structured companies that have already programmed forthcoming investments (Ministero dello Sviluppo Economico, 2018). As usual, Italy is divided between the South (6,1%) and the North-Centre (9,2%). Moreover, the weight of SMEs must be highlighted as they count for most of the Italian firms. In 2017 they were 140.362: 115.773 of them were small and 24.859 medium enterprises, all together counting for 61% employment in limited companies. SMEs also showed very low technologies implement index in comparison to big firms which stressed a high level of innovation (up to 47,1%). The following image shows the diffusion of Smart Factories ■ (enterprises that adopted I4.0 technologies) and the others ■ that have already planned to do the same, in categories for the number of employees (Ministero dello Sviluppo Economico, 2018).



	Totale	1-9	10-49	50-249	250 e oltre
Imprese tradizionali con interventi 4.0 programmati	4,7%	3,9%	9,4%	8,2%	2,9%
Imprese 4.0	8,4%	6,0%	18,4%	35,5%	47,1%

Source: Brancati, R., Maresca, A., & Ministero dello sviluppo economico. (2017) *Industria 4.0 in Italia: diffusione, tendenze e qualche riflessione,* Met 2017-18, 3.

It can be deduced that the bigger the companies are in terms of employees, the higher index they show in the graph. This is due to financial conditions (bigger firms usually have greater possibility of financing) but also to better planning activities. It is estimated that there are, in Italy, about 784.000 family businesses - equal to over 85% of the total companies - and they account for about 70% in terms of employment. In terms of the incidence of family businesses, the Italian context is in line with that of the main European economies such as France (80%), Germany (90%), Spain (83%) and UK (80%), while the differentiating element is the lesser use of external managers by entrepreneurial families: 66% of Italian family businesses have all the management made up of family members, while in France the percentage is 26% and in the UK only 10%, underlining a lack in managerial competences within Italian SMEs (Corbetta, Fabio & Minichilli, 2014).

1.3 A gradual adoption path for firms

As *Luc*a Beltrametti et al. wrote (2017), the concept, usually developed in people's mind, that companies need a technological leap which necessarily and immediately requires very important investments is untrue. Secondly, the idea that once this radical change has been done, it is enough to press a button to start the new plants and enter a new economic dimension is an

even more unlikely scenario to believe. In particular, the process of developing technologies and knowledge, which are needed to enforce this revolution, can follow a gradual path. The latter can trivially consist, for example, in starting to analyse data already owned by the company or in applying sensors on old machinery, also coming to connect different types, enabling the real-time connection between systems, machines, workers, customers, and others. As Pierre Nanterme said in 2016 – during the World Economic Forum Annual Meeting in Davos – "Digital is the main reason just over half of the companies on the Fortune 500 have disappeared since the year 2000". Just a few explanatory words about this revolution, in its trailblazing nature and several changes it involves in companies' structure, from raw materials management to customer relationship management.

1.4 Mass customization made inroads as demand variability increased

Since half of the eighties, it occurred that the complexity of the environment companies dealt with increased considerably due to many factors. While competition became more intense and dynamic in all sectors, there had been a growth in variability on the side of the final demand, which reflected backwards towards intermediate goods. The result is that nowadays companies cope with competitive environments and markets that are no longer simple to decipher and basically stable as in the golden age of mass production. Regarding the final demand, Calvi (1987) recalled that the differentiation (variety) and the change of the consumer's preferences were two phenomena that had progressively prevailed in determining the relationship between consumer and objects of consumption. These trends have continued after Calvi statements through the years. Consequently, consumers' orientation to request customized solutions has grown, in order to satisfy specific needs or to simply differentiate themselves from others. At the same time, consumers have achieved a position of greater autonomy regarding to production, moving away from the status of passive subordination to which they were traditionally relegated in the era of mass production. Henry Ford – the "father" of mass production – stated about customization and available colours for his Ford model T: "You can have it in any colour you want, as long as it is black". On the other hand, the evolution of production technologies and product design has offered companies unprecedented possibilities to respond to the increase in variety and variability on the demand side. It is worth mentioning the articulated set of technologies called *flexible automation.* The distinctive element of automatic machines lies in their ability to perform a wide variety of operations as they are therefore computer-controlled and can be networked within the same company or between companies specialized in distinct phases of one unique supply chain. Zawadzki and Żywicki (2016, p. 107) stated "A measure of flexibility of a manufacturing system is its capability to

perform different tasks and the "speed" at which it can be prepared for a new task. Rapid design of a product means automated design, while rapid implementation of a process is related to use of rapid manufacturing techniques". Flexible automation allows firms to reverse the trade-off between the search for efficiency and for flexibility, characteristic of rigid production technologies. As flexible automation spread throughout the supply chain, the importance held by the economies of scale, linked to the production of large volumes of standardized goods, has therefore reduced. Because of machines capability to carry out a lot of specific operations, changing from one to the other in a very short time and at low costs, it became possible to obtain a large variety of products, in small lots, at low cost. This is the most radical way to achieve *mass customization*. The achieved flexibility makes it possible to involve the customers from the bottom, which is identified with the product design phase, defining a new paradigm seen as the personalized production.

1.5 ICT and the developed ways of meeting customers' requirements

Information and communication technology (ICT) gradually helped to spread 3 main ways in order to meet the new-born variety of demand mentioned before. Firstly, *modularity*, which identifies one specific design in his structure and functions, allows at the same time a high grade of customization on the customer side. A modular product is made up of relatively independent components (modules) connected via standard interfaces. The independence of the components and the standardization of the interfaces therefore represent the distinctive features of modular design (Sancher & Michael, 1996). Thanks to the existence of standard interfaces, the modules can be combined in many ways giving rise to a great variety of final product configurations, which further increase if one or more attributes of a specific module are offered in multiple variants. An example of modular product is the PC, which can be configured by the user recombining the modules that compose it: microprocessors of different speeds, hard disks of different capacities, monitors etc. Through modularity it is possible to expand the range of products offered to the market, meeting consumers' new preferences with customized solutions. Goods become virtual entities, which have a wide number of possible arrangements that become real after the consumer has selected them. Secondly, modularity allows to achieve economies of scale at the module level. Levi's is able to produce 5700 types for Jeans Original Spin, simply combining 227 waist sizes with 25 different leg length (Peppers et al., 2000). Standardization remains an efficiency factor, but is moved upstream, and the key for obtaining such a result lies in postponing and shifting the variety creation to the final stage of the production process (Feitzinger & Lee, 1997).

Another way to meet consumers' requirements is the *flexibility* incorporated into the products. The latter can take over one or more functional attributes offering a variety of solutions that allow users to personalize the product using it. Companies have been practicing this for a long time and continue to explore this form of customization, designing products that contain automatic or consumer-adjustable adaptation mechanisms. Speaking of preferences, after purchasing the product, consumers continue to interact mechanically with the products themselves and to look for best solutions to respond to their continually changing needs.

The last technique to achieve mass customization lies in *services* which integrate tangible products, a method developed thanks to ICT applied, in this case, to finished goods, rather than design and production processes. It is not about offering one or more standard services but creating a variety of possible solutions through services (e.g. the method of payment of the goods) or customizing a specific service in the interaction with the customer. Automobiles are an example, but the emerging scenario is heading towards improvements in technology such as robotics vocal recognition. The new frontier is represented by "smart" products, which allow cognitional interaction between users and products. Customizable services that integrate a tangible product constitute a case of postponement which is similar to the modularity but moved further downstream.

Chapter 2 – Industry 4.0: a new era for mass customization

2.1 New tools of mass customization: the WEB

Information technologies are "the capabilities offered by computers, software, and telecommunications" (Davenport and Short, 1990). Since the 1970s, manufacturing firms have adopted IT-based production management and resource planning systems (Peng, Liu & Heim, 2011). The role of IT has expanded from its early use as a means of automate manufacturing processes to its current status as an enabler of product design, dynamic product configuration, and inter-firm integration (Peng, Liu & Heim, 2011). The world of the web is extremely vast, nearly unlimited, and so are the possibilities offered to enterprises to develop the online business. In their desire to be closer to consumers, many brands have thought of this way in order to meet the always changing requirements. E.g., Nike has been a pioneer in this sector, among the first ones to give people the possibility of customizing shoes directly from company website *nike.com*, where is even possible to apply a personalized writing on the shoe side or create a personal design (Kotler et al., 2018). Moreover, after the customization, the price does not change, which is a very appreciable aspect for the customer. As already said, with mass customization, companies can produce a very wide variety of product-service options, from which the consumer can choose, thus obtaining customized products. A possibility that can be reached through the combination of many modules that are assembled according to the preferences explicitly expressed by the consumer. FCA, as well as many other car manufacturers, allows, through the so-called *car configurator*, to customize a car model choosing for all the options offered by the manufacturer. Companies adopting mass customization must respond dynamically to customer demands and satisfy them as they are identified (Potter *et al.*, 2004). The efficiency of the information flow, from customers to the manufacturer, will affect the success of the strategy (Da Silveira *et al.*, 2001; Stegmann *et al.*, 2006). Product configurator IT enables customers to identify suitable product characteristics that satisfy their needs, and allows them to participate in activities related to the co-design of a product (Piller, 2004). The product configurator idea supports the objectives of mass customization operations, as the assembly activities are virtually conducted by the consumers, thanks to the web interface (Stegmann *et al.*, 2006). In some cases, however, the consumer may not have sufficient knowledge and skills to define his or her preferences analytically as required by mass customization. This situation would lead to confusion, frustration, and therefore the rejection of personalization proposals. To increase the level of customer caring and reduce, as far as possible, the disorientation due to mass customization, *one-to-one* customization was therefore developed. In this case, the ability to interact with the demand is intensively used to

analyse the preferences and propose a customized solution. The variety of products and options to which the consumer is exposed is therefore very small, while the whole process of personalization takes place almost in the background, thanks to the information that the consumer already provided. E.g., websites such as *expedia.com*, thanks to a series of processes for acquiring and filtering the information assumed by their users, manage not to expose the customer to the maximum variety proposed (airline hotel flights etc.) but can reach the proposal of integrated and personalized packages, built right from the clarification of preferences (Kotler et al., 2018). Don Peppers, Martha Rodgers, and Bob Dorf wrote in the late 90s about 1to1 marketing: it is all about "*treating different clients in different ways".* Their reasoning in the book is extremely current and can be reviewed and applied to the web marketing of these days. Moreover, they stated that many companies think to implement 1to1 marketing just because firms know the addresses of their customers' purchases. They might know how to interact with them individually, but they don't adapt products or services to the needs of individuals, even if they offer better services at lower prices than those of competitors. However, to take full advantage of 1to1 marketing, it is not enough to keep up-to-date customer information and interact with them individually: enterprises should take action based on what they know about the requirements of each customer, personalizing the relationship and so ensuring loyalty. The process will be facilitated by the use of the little extra knowledge about the needs of this specific customer, so as to increasingly customize their behaviour with each purchase (Peppers, Rogers & Dorf, 2000). Today the market shows this trend even more clearly: personalization, or the search for exclusive products by end-consumers, is a recurring theme in the field of online sales, especially in the fashion sector. So, to keep up with the times, more and more companies are adopting a personalized approach to be able to offer a unique shopping experience and tailor-made products that meet the needs of each individual customer online. From the productive side, the 1to1 relationship is even a step ahead than mass customization, because single requirements meet unique solutions. Late modifications of product characteristics are allowed making use of the companies' cloud database (Bortolini et al., 2017) as mentioned before with Nike's example. From the company perspective, the value-added is the amount of data collected gathering later, after big data analysis, consumers preferences in order to better forecast future possible orders as well as market trends, and to apply 1to1 marketing. Relationship marketing represents the necessary completion of mass customization in building lasting relationships with customers. With this in mind, the lifetime customer value can be calculated at present or at a potential level, i.e. taking into account possible one-to-one initiatives of the company aimed at increasing it. The company must therefore adopt technologies, define processes, organizational structures, develop services that together enable the activation and maintenance

of interactive relationships with customers. The system of technologies, the organization of interaction-oriented services, defines the field of action of customer relationship management, which represents the operational projection of marketing as a strategic vision of the market approach (Tunisini, Pencarelli & Ferrucci, 2014). Finally, the use of ICT has fostered the development of an increasingly large share of the so-called neo-services. Thus, we are witnessing, in a growing number of cases, the transformation of old services into services which – by maintaining an elevated level of customization – use distance interaction to relate to a broader and differentiated demand than the one accessible in the traditional forms of service. This trend has experienced rapid diffusion in recent years, giving services such as hotels and restaurants booking, online management, using cloud-based databases that can be reached by mobile phone. So, it cannot be a surprising aspect that relationships 1to1 are further spreading, thanks also to these tools networked with each other (Tunisini, Pencarelli & Ferrucci, 2014).

2.2 Debunking myths on web-customization in Industry 4.0

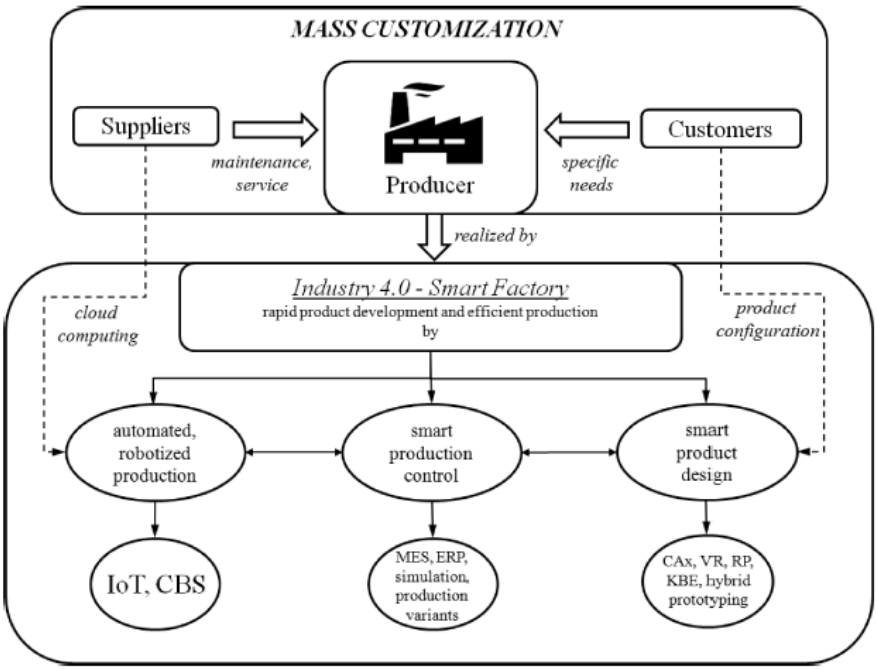
Industry 4.0 can be considered a pervading phenomenon, and the reason is easily explained: it does interest both aspects, i.d. online and offline sales, in addition to the productive field mentioned previously. Connectivity is the biggest revolution in marketing history. Of course, we can no longer consider it a "fashionable neologism" (Kotler, Kartajaya & Setiawan, 2017), but it is transforming many aspects of marketing and its impact continues unabated. Connectivity has prompted us to question many theories and assumptions that are taken as given about the consumer, the product and the brand management. Connectivity drastically reduces the costs of interactions between companies, employees, channel partners, customers, and other stakeholders. This is the main reason why the barriers to entry into new markets are lowering. It also allows the parallel development of products and shortens the timing of brand building. There have been various cases in which connectivity has rapidly changed well-established sectors, with seemingly high entry barriers. Amazon has undermined traditional bookstores and subsequently book publishing companies. Netflix decreed the end of video rentals and, together with Hulu and other platforms, threatened television services. The impact of connectivity on online and offline companies is not univocal. If it is true that online companies have gained a significant share of the market in recent years, nobody can say to be convinced that they will completely replace off-line companies. Similarly, no one would believe that the new online marketing will one day replace traditional offline marketing (Kotler, Kartajaya & Setiawan, 2017). Indeed, both aspects should coexist to offer the best possible customer experience. Here's why: in a world increasingly dominated by technology, the human "touch" is becoming the new

instrument of differentiation. Birchbox, an online cosmetics retailer, has opened a physical store to integrate its e-commerce business. In the shop, customers can use an iPad to receive targeted advice, a system that imitates the customization methods available on the site (Kotler et al., 2018). Zeppos, an online clothing and footwear retailer, strongly insists on customizing interactions with customers in call centres and has made it a successful formula. Many consumers are reluctant to buy shoes online, but just a hint of personal advice from call centre agents is enough to reduce the psychological barrier (Kotler, Kartajaya & Setiawan. 2017). Generally speaking, digital technologies have achieved today a great relevance as they allow consumers to live exclusive and innovative store experience. Luxottica Group, the leader in eyewear production, has invested in digital transformation and changed its way of managing the retail business. It has networked factories with the market and developed unique digital skills in the sector. This profound technological change allows the Group to offer digital opportunities and services to the benefit of the entire optics sector, paving the way for an innovation process for the benefit of both suppliers and consumers. "*Digital is the future of Luxottica and our entire sector. Today new challenges are waiting for us to be able to keep up with the times and satisfy consumers who rapidly change their behaviour and languages, influenced by new technologies. In this transformation phase, we want to be even closer to our optical customers and continue to invest to bring them all the benefits that only digital innovation can guarantee. The watchword is "personalization" of the product and service and with digital in-store, all of this becomes reality*", comments the President Leonardo Del Vecchio (2019). The first novelty presented as an absolute preview at MIDO will bring new ways of digital interaction with the entire Luxottica product catalogue directly to optical customer stores. Consumers will be able to virtually wear any model, in any colour variant, in a completely realistic way, even if not present in the store, thanks to the use of *augmented reality* and advanced proprietary virtual mirroring technologies. Finally, through the interactive screen, for the first time in an optical store, consumers will freely customize Ray-Ban and Oakley models, choosing between colours, type of frame, lenses, several different finish of the temples, or requiring special engravings and dedications to make the model of glasses they want to buy unique. This concept is the birth of the "digital showroom".

2.3 Technologies and mass customization in Industry 4.0

Zawadzki and Żywicki (2016) state that, with mass customization, it is possible to achieve advantages of single piece production (personalization and response to consumer requirements) and mass production (fast production at low costs). Hence its implementation is highly

attractive from a client's point of view, but it is not from the company's as it means risks, especially because of increasing design and manufacturing costs. Moreover, mass customization allows the fulfilment of the expectations of every client by adjusting a product to the client's needs. This is the reason why firms need – in order to apply this kind of production as a competitive strategy – valid forecasting activities. The quicker companies respond to the expectations and requirements of its customers, the higher approval and trust they will achieve. The previously mentioned flexible manufacturing is therefore needed, and so are good forecasting and planning. This provides important information about clients' attitudes. Moreover, Zawadzki and Żywicki (2016) explain that in case of insufficient flexibility or excessive designing phase, customer lead time might enlarge, becoming even unbearable. Although the mass customization concept has been known for years, its implementation is still a huge challenge because it requires the manufacturers to be ready to change variants of products and their manufacturing processes efficiently (Zawadzki & Żywicki, 2016).



Source: Zawadzki, P., & Zywicki, K. (2016) *Smart product design and production control for effective mass customization in the industry 4.0 concept*, Management and Production Engineering Review, 7(3), 106.

Therefore, building smart factories cannot be limited to new solutions in the manufacturing itself, but, as the image above shows, it should embrace company's knowhow of monitoring data as well as rapid testing of alternative solutions through advanced simulations. The development of an efficient production depends on a smart designing phase of the product, on the smart production control and on a last phase in which automation technologies can give the

last leap, up to the moment of reaching the final market. As mentioned before, the innovative technologies – which are the main framework of I4.0 – have been identified as 11 (Federmeccanica, 2016). How do these technologies help to achieve mass customization objectives in a more efficient *modus operandi*? It is evident that the so-called enabling technologies fit for the production of goods in different ways: the manufacturing of some products may need mechatronics and 3D printing while others' only additive manufacturing. This depends on different types of operations firms have to conduct.

MECHATRONICS
- Improvement in productivity - Product and service customization (flexibility) - Exponentially increase products variety starting from customers input

ROBOTICS
- Improvement in productivity - Product and service customization (flexibility) - Reduction of time-to-market

INTERNET OF THINGS
- Product and service customization (flexibility) - Increase of information about processes - Machine to machine communication - Predictive maintenance and fast reacting to consumers changed requirements

BIG DATA
- Increase of information about processes and consumers requirements - Improvement in productivity - Processes efficiency - Consumers preferences analytics

ADDITIVE MANUFACTURING
- Product and service customization (flexibility) - Reduction of time-to-market - Increase products variety starting from customers input - Shorter timing between prototyping and production phases

SIMULATION
- Product and service customization (flexibility) - Reduction of time-to-market - Interconnection and correspondence between physical systems and systems - Processes efficiency

CLOUD COMPUTING
- Cost efficiency - New services offer to consumers - Increase of information about processes

NANOTECHNOLOGIES
- Improvement in productivity - Product and service customization (flexibility)

COLLABORATIVE ROBOTICS
- Improvement in productivity - Reduction of time-to-market - Reduced batch production and small-scale customized production - High precision motion tasks execution

SMART MATERIALS
- Improvement in productivity - Product and service customization (flexibility)

CYBERSECURITY
- Improvement in productivity - Product and service customization (flexibility) - Increase of information about processes

Benefits of I4.0 technologies for mass customization.

Among the 11 technologies, this research will focus on 6 elements that can influence the process of customization more than the others. This classification will not be strict, and it might also embrace other aspects, with a constant focus on the Italian situation, innovation and digitalization characteristic of the 4.0 revolution: *mechatronics, robotics, Internet of Things, big data, additive manufacturing (3d printing), augmented reality*.

2.3.1 Mechatronics

Mechatronics consists of the perfect integration of electronics and mechanics, with the addition of informatics. Having the three poles interacting with each other means also coordinating them correctly. The mechanic systems start being "smart" as they react to the changed external reality, going back to the optimal working conditions (Beltrametti et al., 2017). This is possible thanks to the improvements – mostly in informatics – where analogic has been substituted by digital arrangements that can manage mechanics of subsystems in a much more flexible and configurable way. An example of a mechatronic system which allows high customization that has evolved in this sense is the photocopier. The first photocopiers were electromechanical systems that exploited the properties of certain substances to be charged electrically when hit by a light beam. Today printers are multifunctional, combining the capability of enlarging or reducing images, placing multiple pages side by side on a single sheet, adding writing and much more all into a single device, giving users a high range of personalization possibilities themselves as a "service". Moreover, firms which adopted mechatronics innovations have shown a growth in productivity, in the offering of new services to the customers and in flexibility, intended as personalization of product and service (Federmeccanica, 2016). Laser cutting might be the most interesting application to implement. It basically consists of the usage of lasers to cut materials of every kind and allow a very high grade of customization in the production. Surfing the web, it is even possible to find companies that offer laser cutting as a service in order to satisfy people projects, starting from scratch. This is the case of *ideatagliolaser.it*, a company from Taranto that is specialized in the laser cutting technology to create every idea that customers upload as a project in the company web site. Among the Italian SMEs, laser cutting is quite spread as it counts for 44% between firms that declare to use at least one of these mentioned technologies. Companies specialized in the production of eyewear, gold jewellery and pieces of furniture are the greater users with peaks of 90% (Laboratrio Manifattura Digitale, 2017). Thanks to these enhancements, e.g., factories located in Belluno district of eyewear are able to produce 80 million glasses a year, counting for 80% of Italian production in this market, with a high ability to adapt and respond to consumers' requirements (Bramanti & Gamabarotto, 2007).

2.3.2 Robotics

Collaborative robots are machines that can share the same working spaces of humans in order to achieve productive targets: the safe integration is guaranteed by skin sensors, which allow robots to recognize the presence of human beings. Compared to the industrial robots – which are a steady factor in many companies' supply chains since decades already – these so-called *Advanced Manufacturing Solutions* can be found in several workstations. As they can be easily reprogrammed, it is possible to have them also communicating and collaborating machine to machine. The technology mentioned above can also be applied in logistics operations and in all those repetitive actions which require high precision of motions. With several improvements, robots are likely to become even smarter, developing machine learning capabilities, leaving the fixed position in the factory that they used to have. Humans will soon be able to focus on the more specialized component of the manufacturing process as the aim is to achieve mass and customized products creation always faster. Robots have brought a new source of flexibility and a big leap in mass customization production possibilities. Nigel Platt, Business Line Manager, Welding, and Cutting, at ABB Robotics has recently said during an interview for the online magazine Automotive Industries: "robotic automation is providing greater flexibility for OEMs to make more models on the same lines, from framing car bodies to assembling cylinder heads". And again, replying to the question on how important smaller batch sizes with higher flexibility are, he said: "Consumers today expect to customize every aspect of their car, from the paint finish to the entertainment system. The number of possible combinations has increased exponentially. This is a huge shift for such a capital-intensive industry that has traditionally been set up around economies of scale and large runs of the same product. […] In a word: "flexibility". […] This means greater engineering efficiency and faster production ramp-ups". Collaborative robots are spreading faster among big companies with the average of 20% of diffusion while small enterprises show just 5% (Ministero dello Sviluppo Economico, 2018). Another research (Laboratorio Manifattura Digitale, 2017) has underlined that one out of two interviewed companies that have adopted at least one technology of the 11 mentioned uses robotics since it can be implemented in many different processes and it guarantees high flexibility, with possibilities of application in operations of different industries (Laboratorio Manifattura Digitale, 2017).

2.3.3 Internet of Things

It is not easy to explain in simple words *Internet of Things* because a univocal definition does not exist. The founder and CEO of Burrus Research Inc. has claimed “The Internet of Things (IoT) is a combination of networked sensors and machines that enable machine-to-machine communications. Enabling technologies include the Internet, advanced cloud services, wired and wireless networks, and data-gathering sensors, making the system instantaneous anywhere, anytime. Advantages of IoT include the ability to monitor and control, real-time asset management, faster response times, major cost savings and, perhaps the biggest advantage, the ability to predict and prevent”. Anyone, reading these lines, might feel a bit confused: IoT is about all these innovations and could not be summed up in few words. Luca Beltrametti et al. (2017) have written that IoT cannot be seen as a mere technology which enables device to device communication but more precisely as a mix of 4 ingredients: *things*, *applications* used by people, *data and algorithms,* and *processes*. *Things* are the devices equipped with sensors and actuators which implement the possibility to receive orders about actions to do allowing high flexibility. Moreover, people can use the web or mobile *applications* to get more information in order to take better decisions. Applied to the SCM, the monitoring console of production line provides data gathered by telemetry which can be used by an operator for managing the machinery tools. *Data and algorithms* – which are fundamental to analyse the first – are also extremely typical of IoT. Predictive maintenance is an example of usage of data in this way: the analyses through algorithms optimised on the collected data allow operators to know whenever something is going wrong in the operations to have machines always performing efficiently. *Processes* are the more important keyword: these are now more efficient and faster, improved also in safety and costs. In several cases IoT has been applied to existing operations through the implementation of data – later analysed – collecting systems, making it possible to further increase processes and decisions efficiency regarding the activities. This has made it possible to implement lean production systems in all the operations in factories, allowing to meet consumers requirements with more precision, but also being connected with suppliers, thanks to the continuous flow in information from sensors that is processed and networked with the supply-chain (Dutton, 2013). Sergio Crippa of Hawlett Packard Enterprise clarifies why he considers IoT a key sector: "It helps the clients to transform their data - from the edge to the cloud - in intelligence capable of promoting transparent interactions between people and things, creating personalized user experiences and exploiting AI and machine learning to act and react in real time"(p.42, Digitalic 12/2018_n. 79). In regard to manufacturing activities Giovanni Brusoni of SAS commented: "Smart factories will be able to carry out

intelligent, complex and increasingly autonomous operations. The sensorized and connected real-time factories will be able to self-diagnose their own state of health by providing yield and quality. They will be able to anticipate market demand and activate opportune supply and production plans based on the needs to be met." (p.45, Digitalic 12/2018_n. 79). In its industrial application IoT has been identified as the most spread technology among Italian firms in 2017 (Ministero per lo Sviluppo Economico, 2018). Another study (Laboratorio Manifattura Digitale, 2017) has stressed that the technology is extensively used in the sectors of textile and electric devices, with average in the latter of 50% of diffusion among adopters of at least one industrial technology.

2.3.4 Big Data

Big data are usually explained in all didactic books through 4 V: Volume, Velocity, Variety, Veracity (Beltrametti et al., 2017). The first refers to the huge volume of data produced by productive machinery. Velocity concerns the continuous flow generated by firms' operations, supply chain, production line and social networks. Variety stands for the coexistence of different sources and types of data such as database, e-mails, photos etc. In the end veracity is the more delicate and critical aspect of data collecting and storing activities. On Facebook 4,5 billion people tap "Like" every day: an enormous amount counting for more than half human beings on the planet (Beltrametti et al., 2017). But how does Facebook handle such a number? In order to save and later analyse these data, as they reveal strategic information about consumers' preferences for those who intend to create services or products that can have great value, it has been clearly fundamental to create low-cost ways to store. The increasing complexity of the markets and the hypercompetitive context, in which companies operate, pushed marketing managers to make greater use of Customers Analytics, and big data are the best tool to do so. With this term, it is meant to indicate all the activities that aim to collect, integrate, rationalize and analyse data from different sources in order to generate an in-depth knowledge of the consumer and predict their behaviour. The main modules of a Customer Analytics system include: data collection subsystems (integrative tracking through sensors and tagging systems), and data integration in a single data warehouse, data processing and data mining platforms to extract the relevant information, applied statistical models for data analysis aimed at producing informative reports, for presenting results to marketing managers and to support strategic decisions. Using of data, information technology and statistical analysis makes it possible to improve the knowledge of customers in order to optimize the management of customer relationship management, logistics and retailing activities. An example of the effective use of customer analytics is Netflix. The huge investments in Analytics have in fact

made it possible to develop techniques and algorithms to understand customers and personalize the experience of interaction with the platform. In this way, the monthly *churn rate* has been significantly reduced and at the same time have been fed with information full of innovative ideas and processes for the development of new show films and TV series (Kotler et al., 2018). Therefore, the task of big data is precisely offering an alternative to the traditional database for specific areas of use. It is all about Big Data Analysis as, e.g., the already mentioned predictive maintenance shows again: the obvious consequence once data are collected and analysed is that enterprises can have important information about the machinery thanks to telemetry's data coming from the Manufacturing Execution System. Moreover, retailers use big data to present a personalized set of products to their customers, because it is usually needed a high storage and analysing capacity in order to learn from previous consumers' purchases and to present sufficient possibilities of customization. This has been the heartbeat behind Amazon success, but most companies need to implement it. Claudio Broggio, Innovation Consultant for SAS, has claimed: "the challenge for Italian SMEs is to manage to use a large amount of data available to make processes efficient and at the same time to serve customers in a more specific and preferences-based way" (p. 42 Digitalic 03/2019_n. 82). Big data have shown a lower diffusion in Italy in comparison with other technologies as SMEs seem to highlight low adoption index, but big enterprises rise the cumulative amount as they reach 20% average in 2017 (Ministero dello Sviluppo Economico, 2018).

2.3.5 Additive Manufacturing

Additive Manufacturing is also another interesting aspect among the most spread technologies of industry 4.0 as it wholly expresses the idea of personalization of the product. Additive manufacturing creates objects starting from digital projects by adding progressively layers of material: from the geometry described in the digital file sections are created and transposed into real material, progressively producing the three-dimensional object. 3D printing technology development has almost achieved no customize solutions' costs and no waste of materia prima, but the production timing is still not good for massive quantity production. Additive manufacturing is nowadays spread in sporting goods, eyewear and jewellery manufacturing sectors as products are small-sized and so easily 3D printed. One example is *Yaniku* (the word that stands for *Unique* in Japanese), the first vision-centric eyewear in the world created with a custom-made 3D frame, especially for the single consumer as the company website suggests. Thanks to 3D scanning technology and advanced algorithms, Yuniku glasses are designed and entirely based on people's faces and visual needs, matching perfectly the requirements. According to the research conducted by Ministero dello Sviluppo Economico (2018), 2%

among Italian companies has already achieved the end of the adoption path for this technology. Speaking of sectors, another study (Laboratorio Manifattura Digitale, 2017) underlines that the technology is used by eyewear and jewellery industries, but shows an incredible adoption between sport items producers with 100% diffusion among adopters of I4.0 innovations in the sector.

2.3.6 Augmented Reality

Augmented reality is the last keyword of industry 4.0 which has brought a real change in developing products and creating possibilities of customization. If once an airplane prototype had to be produced and tested to understand his capability of being a good new model, nowadays it is possible to simulate with high precision its behaviour even if it has not been built yet. This attitude is spreading in the various sectors: from simulating the resistance of cars to accidents to the capability of a bridge. On the customization side, programs of high precision level can forecast the time needed to produce a piece of something that might be just a project or a digital image. Customization through the creation of tailor-made product has so been favoured because companies, before starting productive machinery, can have a full forecast of how operations will be in terms of timing and possible variants of the products design. The basic idea for companies is about creating the called "digital twin" for every object of the plant. From simulating to experiencing a hypothetical reality with high precision. An example of practical application is Snapfeet, the original app ideated by Trya that allows virtual testing of shoes when purchasing online. Thanks to the innovative 3D reconstruction technology and sophisticated test software, the app suggests how the shoe dresses the foot in different sizes, simply showing perceived comfort. This technology is the most unknow between Italian companies and this is the reason why it shows very low percentage of adopters. It has been found in less than 0,5% firms and it is the only one, among the 11 enabling technologies, to stress less than 5% diffusion among big enterprises in Italy (Ministero dello Sviluppo Economio, 2018).

Chapter 3 – O bag case study[1]

3.1 The company

O bag is an Italian company based in Padua (headquarters in Campodarsego), which entered the international fashion design market in 2009, creating products from innovative materials and offering made in Italy style and quality. The firm is leader on the market in customization combined with the use of cutting-edge materials, such as XL Extralight, through a product offer of Made in Italy design, ranging from bags to watches, from glasses to bracelets, from shoes to home design. The first product launched was the *O clock* presented at *Salone del Mobile* in Milan in 2010, followed by the iconic *O bag* introduced at MACEF in 2012. Revenues are mainly originated by bags (75%) and watches (15%) but the range of product is not limited to these ones. The company is currently managing and seizing the potential of the various markets, thanks to a retail development started in 2012 and counting today more than 400 mono-branded shops all over the world: 40% of these are directly managed and owned by the company, employing 360 people. O bag also sells through 500 multi-branded shops all over the world. The business is now present in 50 countries, with a sensitive approach to the evolution of consumers' requirements. The founder *Michele Zanella* claims on the company web site: *"Our most important goal is to develop our retail business both in Italy and abroad. […] we envisage reaching 500 new O bag stores in 2018, broadening our presence in China, Saudi Arabia and Mexico among others. Moreover, we are planning important investments to improve logistics, offer our customers a better e-commerce platform and develop really effective social and marketing communication"*. These words are the proof of the great growing that the company is experiencing during the last few years, with a solid financial performance (almost 90 million revenues in 2018), employing nearly 120 people between headquarters and the productive plant. The production activities are both run internally – plant in Corso Stati Uniti, Padua – or in other cases externally. The keys to success are *design, "democratic" price positioning, materials and customization*. The business was indeed started as design-oriented in 2009 with the launch of its iconic watch. Nowadays its products are still a mix of fashion and design, the so-called *easy fashion*. Moreover, the offer price range allows to reach both mass and premium markets, from low to high income consumers.

[1] The information contained in this chapter was collected from the company's website and suppliers' website, from the company itself through interviews to the *Head Of Online business Tania Grigolo*, *IT Manager and Technical Supervisor Luca Bernardi* and *Project Manager Federico Batelli* during the thesis student's internship at O bag Headquarters in Campodarsego.

3.2 Mass customization and O bag: a winning combination in the I4.0 era

The firm is the perfect example of mass customization, applied in this case to the fashion accessories market. O bag world is based on the "O" concept. It stands for One (unique), Own (belonging to oneself), Original. The claim is in fact "make it yours": consumers can customize and make their own accessory unique, by changing one or more components. The product becomes custom-made, full of colour and mixed elements. The customization possibilities are almost unlimited as the table below shows.

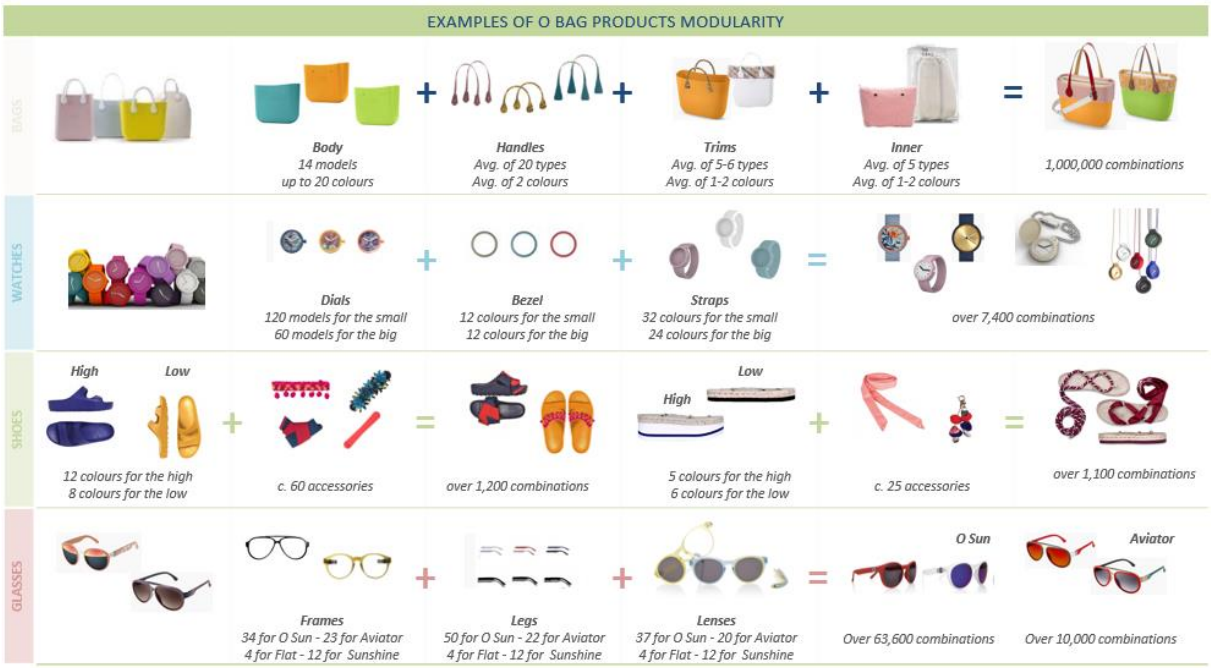


Table by Group Managing Director Alberto Bartalozzi at Unipd Conference - 15/02/2019

The products offer exemplifies mass customization: a wide range of products in a larger number of possible variants based on the modularity concept. One "O bag" is composed of body, inner bag, trim and handles or shoulder strap. As stated in the image above, just in the case of a single bag it goes up to 1 million combinations. Moreover, the founder Michele Zanella claims that O bag was born on the idea of keeping a democratic price, adopting "different configurations pricing", so giving consumers the possibility to find the solution also depending on their purchasing power. The price can easily scales up or down choosing between the accessories to buy because of the different prices they might have (e.g. various features available such as faux leather, eco-fur or wool trims). The "make it yours" concept has been extended to all the product offer, from shoes to sunglasses.

The success of the company's mass customization strategy is based on the knowledge of the preferences of its own end-consumers. In the age of Industry 4.0, the company is progressively

integrating technologies such as *big data, mechatronics, cloud computing, cybersecurity* and *3D printing* into its business.

MECHATRONICS
- New bag-body drawings and textures creation with laser-cutting - Cutting-edge and industrial-designed solutions

CYBERSECURITY
- Protection of computer systems and information in digital format from internal and external attacks

CLOUD COMPUTING
- Cost and projects development efficiency - Information sharing - Increase of information about processes and clients

BIG DATA
- Increase of information about processes and consumers requirements - Segmentation of consumers base - Targeted actions – cost efficiency - Consumers preferences analytics - Forecasting activities

ADDITIVE MANUFACTURING
- Product and service customization (flexibility) - Reduction of time-to-market (prototyping activities) - Increase products variety (shoes, bracelets)

Effective benefits of I4.0 technologies – The O bag case.

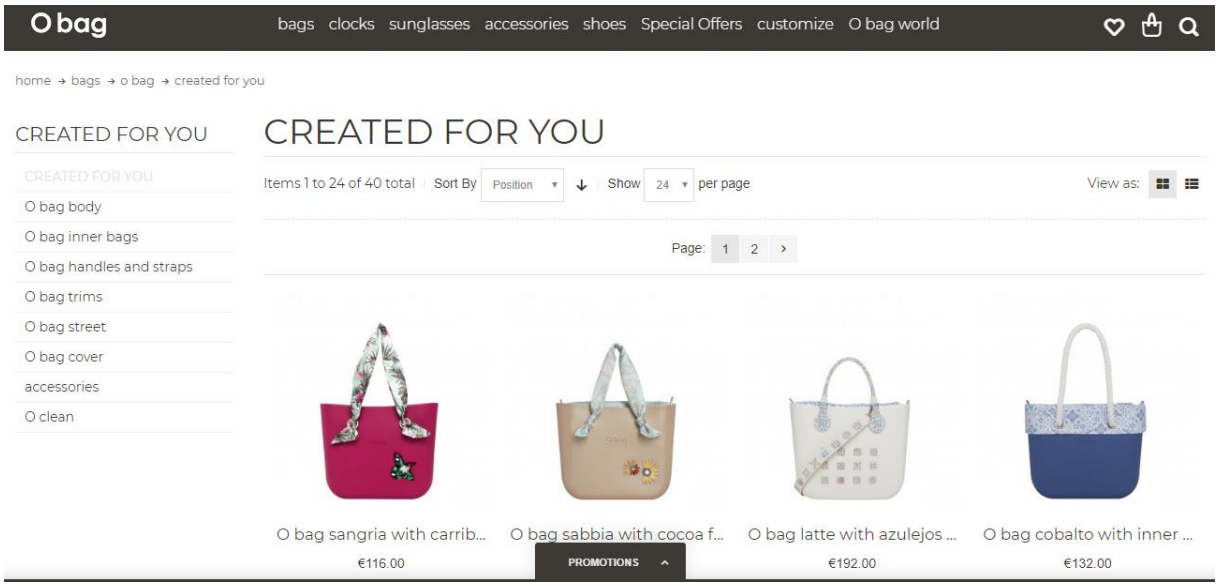
The integration occurs sometimes internally or in other cases engaging with suppliers already technologically provided with 4.0 technologies. This might be the case of the experimentation of the use of laser cutting that the company is carrying out at an external supplier plant in order to personalize its iconic bags in completely new ways. This technology makes it possible to decorate the bag body burning a top layer following precise drawings or cutting precisely the bag body, which would increase the already wide range of custom-designed solutions available. E.g., another firm supplier and producer of some products for O bag called *Finproject* has already been prototyping products to launch with 3D printing, finding the perfect design in collaboration with O bag product team. Internally the company makes extensive use of technologies such as big data, cloud computing and cybersecurity mostly since the headquarters relocation in Campodarsego in 2017. Through an Enterprise Resource Planning (ERP), the integrated management of main business processes often in real-time and mediated by software and technology, an incredible amount of data is managed to reach a data centre located on cloud and of course secure from any external attack thanks to specific cybersecurity software. This is linked with various modules that are used to manage separately – in order to implement more specific software – logistics, accounting, cash flow control system and a business intelligence. From the analysis of big data coming from these centres, the company can work on the single

customer precisely, e.g. implementing a segmentation programme according to different parameters studied. The forecasting activities are therefore conducted at the end of the previous year and are based on the analysis of the revenues starting from macro categories up to reach the colour of the single trim of a single *O bag*. Consumer preferences also vary from country to country and, for a company as O bag which operates in more than 50 countries, this must also be considered to predict production activities. The main data certainly comes from BI and customer care. The latter gives to company's management information about the after-sale and, from these data, targeted actions can be studied. E.g., if many customers find shipments too slow, the firm will work on the logistics side and so on. All this information is gathered together trying to reach the perfect segmentation of clients' needs. Targeted campaigns are later created on Facebook and social media, where the company can reach the single customer only thanks to the activity of specialized analysts able to read the big data coming from the software. As a matter of fact, specific skills are needed to do this. The more *touch points* the brand gains with the customers it aims at and the more likely it will be to have them to buy the product. In addition thanks to big data, the company takes information to design future collections, which must try to better measure customer tastes. The future goal for the company is to reach a visualization of the website from the single client point of view, according to his preferences.

3.3 1to1 marketing: "created for you"

Since the earliest times, O bag has focused on customization and customer satisfaction by offering a wide range of products in various colours and with different customizable features. Thanks to big data analysis, a specialized team creates the product offer following consumers requirements. In addition, the company has developed a solid e-commerce part that integrates perfectly with the network of mono-brand stores it has developed (today more than 400 in the world). On-line customers find a configurator that reproduces the actual situation that would happen in the store, where a wide selection of customizable features for the product are displayed and the end-consumer can build his own unique bag indulging himself. As previously stated, a characteristic of mass customization could be to bring the customer to a sort of disorientation because of the offer which can in some cases be too vast or not adaptable to the preferences of all customers. Furthermore, not all customers are prone to this type of shopping. Some consumers may not have sufficient knowledge and skills to define his or her preferences analytically as required by mass customization. As said before, to increase the level of customer caring and reduce, as far as possible, the disorientation due to mass customization, *one-to-one* was therefore developed (Peppers, Rogers & Dorf, 2000). In this case, the ability to interact

with the demand is intensively used to analyse preferences and consequently propose a customized solution. The variety of products and options to which the consumer is being exposed is very small compared to the rest. In the case of the Venetian company, a *"created for you"* category is associated with each product on the company's site.



Source: *https://www.obag.eu*

In this category the customer can find items already personalized in different variations with taste and particularly interesting combinations, which may vary according to the themes and characteristics of the proposed collection. Thanks to big data, the company knows the preferences of the individual customer who surfed the website and can re-propose the items discarded or left in the check-out cart through other platforms or show related items that follow the customer's tastes. Even data related to the number of abandoned shopping carts are also taken into consideration and contribute to the company forecasting activities. These “created for you” combinations are thought specifically by an expert team on the product, to try to get an attractive proposal from an aesthetic point of view for every sort of client that the website may attract. In doing so, the customer can opt for a solution that allows him to obtain a high-level, yet ready-made bag, or he can prefer to take inspiration from that and change it in some variants, reaching his own creation. These created bags are photographed and transmitted to the store’s manager and wholesale clients in order to replay the offer in the shops. The final consumer can indulge himself in seeing all the different proposals in the store and get to see which is the best combination. As it is for the online, the customer in the store can, with the assistance of the store clerk, also personalize a bag already proposed in the store, or create his own starting from the proposed ideas.

Conclusions

Industry 4.0 is only at its beginnings in Italy but in the short to medium term it could heavily influence Italian production. Most companies are planning huge investments and the Government's plan has given them an important boost. Only the 2,5% of Italian enterprises claims not to know the 4th industrial revolution (www.repubblica.it, June 26th, 2018). The implementation of the technologies is not easy, above all, in an entrepreneurial system made up of SMEs where the enterprises' financials are chronically weak. These technologies, once implemented, will be increasingly important to achieve customizing products and services, answering people request faster and faster. As a matter of fact, consumers do not look anymore for standard services but rather tailor-made and tools such as big data can allow companies to get to know them perfectly. Starting from the client's point of view, firms aim at interacting 1to1 with consumers. Furthermore, the implementation of other technologies such as laser cutting, collaborative robotics and additive manufacturing can help companies in providing customized products thanks to innovative productive ways and processes efficiency, increasing flexibility and shortening even more the time to market. The ability to integrate the production line and the online and retail parts is then an important fact because strategic coherence and consistency are the keywords. The considered O bag case is the perfect example of Italian SME which is improving its technological level, and taking off flying the 4.0 route but still lacking in some competences and investments to do the final leap in order to finally land in the 4.0 world. Once that the lack of competencies and the financial weakness will be overcome, the Italian entrepreneurial system will benefit of a new boost in productivity and efficiency, going back to the position of economic leadership it used to have in the world scenario.

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