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Smart and digital Agrifood: evidence from six case studies

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To my grandparents who lit so many candles

ABSTRACT

This is a comprehensive study on the impact of technology implementation in the Italian agri-food industry. Information and evidence was collected from six case studies done in Italy.

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PREFACE

Food and drink are two of the most important industries worldwide. The primary role of the agri-food industry and its effect on the Italian economy can be better understood by analyzing the value of food products in the Italian consumer market. This value was worth 71 billion euros in 2017 according to Italy's Gross Domestic Product (GPD) value, a 10.6% of the country's total value for that year.

Most Italian drink and food businesses are family owned medium and small enterprises that have been passed on for generations. These "mom and pop" businesses are multi-generational and the decision making process is often conflicted by their willingness to use innovative approaches to run their business. According to Italy's 2010 Agricultural Census, 76% of family owned businesses are connected to the agri-food industry. Many of them are characterized by their poor performing reputation, this due in part to the age difference that exists in family members with authority to make changes in the business structure and their potential to manage and help the family business grow. In Italy, the mean age of family control in the family's core company is 65 years. Research shows that older generations are less likely to embrace innovative ideas to develop business growth. The environment for innovation in family businesses improves when more generations of the owning family are actively involved in the business. In 2013, for each agricultural entrepreneur who was younger than 35 years old, there were 12 entrepreneurs who were older than 65. As a result, they are less likely to adopt innovative ideas and are considered low tech.

Innovation can deliver significant benefits, efficiently tackling a critical business process. Tech enabled businesses have higher chances of improving success rates and generating profit. High-tech businesses help drive improved customer experience through the use of new and improved products and services. Emerging technologies are impacting the future of businesses operations and accelerating the pace of change in every business model.

They are mainly process – innovation oriented and they use mainly new technologies developed by upstream industries. So innovation occurs throughout equipment and capital

good investments. In addition, most of the innovations are incremental rather than radical.
They have difficulties to access finance a well as internal competences for investments in in-house R&D activities. For this reason, it's fundamental for these SMEs to be able to acquire and manage external knowledge. A way to develop innovations in such scenario is developing relationships with university or research institutes.
Developing the right business plan is critical for keeping up with the changes in supply and demand as well as the consumer needs and behaviours that have changed in recent years. A good example of behavioural change would be the fact that food and wine are now considered complex and multidimensional consumer goods associated with hedonistic and cultural aspects. Furthermore, there is an important aspect to every business plan: understanding and defining the customer profile and their needs. Market segments are often represented by consumer profiles. Two consumer profiles emerged in the last three years: the high-priced and the low-priced consumer, also known as Low Price and Golden Shopper consumer. High-priced consumers are attracted to high quality, expensive products whereas the low-priced consumer prefers to pay less even if it compromises the quality of the product or service.
Furthermore, people have less time to cook and an increasing percentage of meals are consumed outside of home. For this reason, even traditional companies should start to produce ready to eat meals.
In this context, Industry 4.0 could help companies to find solutions to these challenges. Even if several technologies have been already implemented, further improvements need to be done.
Technology is useful to monitor processes and to reduce mistakes as in the manufacturing industry. But in food and beverage sector, it is even more important to guarantee the traceability of products, the food and beverage safety as well as more sustainable behaviors. In fact, sensors and drones are employed to forecast weather conditions and plant well-being, decreasing fertilizers, pesticides and water consumption.
Smart agri-food finds a place in the 4.0 Industrial Plan presented by Renzi and by the Ministers Calenda and Padoan. There are incentives to support the purchase of new technologies in the agricultural and agri-food sector. The main objective is to reach 10 percent of precision agriculture within three years.

The purpose of this thesis is to study the changes brought about by new technologies in terms of productivity, strategy formulation and organization management. In order to achieve this goal, I selected six companies from different sectors. Astoria and Berlucchi & C. are wine producers located in two different Italian regions: Veneto and Piedmont respectively. Società Agricola Porto Felloni is an agricultural company located in Emilia Romagna which produces different cultivations, from corn to tomatoes. Oleificio Zucchi is a company located in Lombardy which produces different types of oil. Latteria di Soligo operates in the dairy sector by producing cheeses and milk and finally Res Uvae is a demonstrative agricultural company based in Emilia Romagna. The last one is a particular firm because its mission is testing the most interesting and innovative solutions available in the market.

Most of the companies analyzed are small or medium sized, family owned enterprises. I chose not to select large companies because I wanted to concentrate my study on the firms which characterize the Italian Industrial context.

I developed the cases by interviewing the owners, the employees and the technicians working at the selected companies. My goal was to find out why they decided to invest in advanced technologies, the changes involved and the impact these changes would have on their businesses future. I was also interested in the advantages and the difficulties met in the implementation process. In particular, I discovered that the main obstacle is related to people, both in terms of competences and human mentality. Training is essential also because technology is changing the skills required. More professional technicians will be needed. Furthermore, more interdisciplinary skills will be required to support innovation. These are related to innovative technologies, innovative models and innovative designs.

Despite the difficulties, technologies seem to be fundamental to compete and to gain additional profits in the future. Anyway it is a utopia thinking that technology will substitute humans in the future.

Based on the majority of cases studied for this report, technology should be perceived as something that supports and facilitates the human decision making process, not something that will change completely the way in which work is performed.

In the first chapter I described the Industry 4.0 from an industrial point of view. I also analyzed the different national policies which support it. Specifically, I took into consideration the measures taken in Italy, Germany, France, European Union, USA and China.

In the second chapter I focused on the agri-food sector. In the first part I provided a general description of the industry by analyzing turnover, exports, imports, productivity, workforce. In the second part I described the technologies implemented in the food, wine and agricultural industry.
In the third chapter I described the different technologies implemented in the Agri-food sector from a theoretical point of view. In order to analyze them, I used several scientific papers published in the last 10 years.
Finally, in the fourth chapter, I analyzed six companies from different agri-food sectors to understand the way in which technologies have been implemented and the changes they have brought about.

CHAPTER I

Industry 4.0 definition

The first industrial revolution occurred at the end of the 19th century when the steam engine powered factories. Electricity allowed for mass production at the beginning of the 20th century and in the 1970s the industry became automated: electronics and ITT were used to mechanize production. Now we are in the wave of a new technological advancement known as industry 4.0.

Industry 4.0 identifies the new technologies employed in manufacturing. This new revolution unifies advanced production and operations techniques with smart digital technologies to create a digital enterprise that is not only interconnected and autonomous but it can also communicate, analyze, and use data to drive intelligent action back in the physical world. This new revolution allows companies and people to be connected with smart technologies. This transformation is powered by nine technological advancements: autonomous robots, simulation, horizontal and vertical system integration, industrial internet of things, cybersecurity, cloud computing, additive manufacturing, augmented reality and big data analytics.

Robots have been used in production processes for many years, but they are now evolving to offer a greater utility. They are becoming more autonomous, flexible and cooperative and they will be able to work side by side with humans.

Simulation is already used in terms of 3D simulation of products, materials and production processes and in the future it will be used also in plant operations.

With horizontal and vertical system integration, the capabilities of entire companies, departments and machinery can be configured and networked to function simultaneously. More practically, simulation can be used to understand the future behavior of a system.

Internet of things allow different electronic devices to be connected, communicate and interact with each other over the internet without human intervention as they're embedded with internet connectivity that enables them to be controlled and monitored remotely.

Cybersecurity refers to the protection of networks, devices, programs, and data from attackers, or unauthorized access by hackers.
In the past most companies relied on close monitoring of production processes. Industry 4.0, which represents the digitization of systems, allows greater connectivity and communication between machines that can plan an entire production process and make changes during production. Secure, reliable communications other than sophisticated identity and access management of machines and users have become essential.
During the past years, several industrial-equipment vendors have joined forces with cybersecurity companies through partnerships or acquisitions.
Cloud computing refers to the practice of using web base networks and servers to store and manage data rather than using hard drives and local servers on a personal computer.
Additive Manufacturing refers to the process of 3D printing, a process that uses layers of joined materials to create three dimensional objects. If used and implemented correctly, Additive Manufacturing can significantly reduce material waste, time and money.
Augmented Reality is a type of virtual reality that aims to duplicate the world's environment in a computer. An augmented reality system generates a composite view for the user that is the combination of the real scene viewed by the user and a virtual scene generated by the computer that augments the scene with additional information. The main goal is to create a system in which the user can't understand the difference between the real world and the virtual augmentation of it. Today it is used in entertainment, military training, engineering design, robotics, manufacturing and other industries such as fashion.
Big data analytics refer to the analysis of a large amount of data to discover unknown information, such as customer preferences.
Industry 4.0 creates what has been called a "smart factory" where production processes and plants become digitized, computer operated systems.
During this transformation, sensors, machines, workpieces, and IT systems are connected to a chain reaction process controlled by computerized systems. These connected systems (also referred to as cyberphysical systems) can interact with one another using standard Internet-based protocols and analyze data to predict failure, configure themselves and adapt to changes.

Industry 4.0 will make it possible to gather and analyze data across machines, enabling faster, more flexible, and more efficient processes to produce higher-quality goods at reduced costs. This in turn will increase manufacturing productivity, shift economics, foster industrial growth, and modify the profile of the workforce (Rüßmann, 2015).

Are companies ready?

According to a 2016 survey published by the McKinsey Global Institute, the industrial sector is lagging behind other sectors in terms of digitalization. Advanced manufacturing, oil and gas sectors have already entered into the digitalization process, whereas basic goods manufacturing, chemicals and pharmaceuticals are still in the first stages of the process.
The McKinsey Industry 4.0 survey took into consideration more than 300 manufacturing producers in Germany, Japan, and the United States from January 2016. Results demonstrated that only 16 percent of manufacturers have an overall Industry 4.0 strategy in place, and just 24 percent have assigned clear responsibilities to implement it (Digital Mckinsey, 2016).
According to Mckinsey, companies need to undertake five steps before jumping into the industry 4.0 world.
1. "*Prioritize and scale up*": organizations need to understand their customer's profile and their needs plus the price they're willing to pay for the products and services they seek. They can gather this information from surveys and interviews or by asking analysts for this data. In addition, they should investigate the degree of innovation or disruption and analyze the organization in order to make an overall assessment of the company's capabilities. Without a plan in place, jumping straight into Industry 4.0's methodology could be very risky for the company.
Bringing a company up to speed with technological advances means there's a high price to pay for putting in place innovative ideas, applying new technology and dealing with the lack of absorptive capacity, a company's ability to be responsive and assimilated with new tech. This is the capacity to become more and more familiar with technology, it's the degree to which a company is able to recognize innovation and technology in order to integrate it in the process and it depends on the amount of innovation and R&D a company does and has done in the past. In other words, if the company isn't familiar with this technology or if the organization hasn't been permeated with previous technology, jumping

upon the recent technology might be the worst thing to be done because the company doesn't have the tools needed to keep up.

2. "*Adopt a test-and-learn approach*": new technologies change the environment frequently. Nowadays, planning has become less relevant and reliable. If you want to remain competitive, you have to keep these three points in mind: agility, experimentation and learning.

Once digital solutions have been implemented, they should be immediately tested with the target customers to determine if their needs and prices have been met. If an idea doesn't work, it should be cut off immediately.

3. "*Put foundations in place*": companies need to move towards a two speed IT infrastructure, to maintain the efficiency of existing operations and provide the necessary capacity and speed required by the new activities. In addition, new job opportunities will become available to fill the new positions.

4. "*Treat data as a competitive advantage*": data is particularly important as it fuels algorithms which support forecast analysis and reconsider decision making processes. For this reason, companies need to pay attention to data. There is the risk of malicious attacks and it's important for companies to increase the level of cybersecurity.

5. "*Work across functions, and manage change in the organization*": Industry 4.0 is not something that interests only the IT personnel. It involves all the processes as it affects every part of an organization. Fostering cooperation among different departments is critical as these technologies have a huge impact in the way in which people work. It's important for organizations to put in place a training and development program to properly train and educate employees so they all have a consistent experience and background knowledge.

Organizations should research the different options they have available in selecting the best technology for their company. They need to evaluate the pros and cons of adopting Industry 4.0. They should offer their employees all the tools to use the technologies in the most efficient and effective way.

Finally, they have to remember that technological change is not an immediate process, on the contrary, it's a transitioning, thoughtful approach to change.

Industry 4.0 is a very challenging process to undertake. Most people are hesitant to change, especially when it relates to technology. Some people believe that the concept is poorly defined and expectations are unrealistic. In a global survey from 2013, 88% of the respondents said they have not fully understood the underlying business models and its long term implications for their industry (European Parliament Briefing, 2015).

Companies must be open to change and partner up with other firms, such as suppliers and distributors of products, technological companies and infrastructure suppliers such as internet service providers to adopt and use standards that allow the collection of data. In fact, this partnership between the above mentioned organizations is essential to ensure the exchange of data between machines, systems and software becomes a universal resource that everyone has access to.

If data and protocols are recognized only nationally, data collected becomes limited to and compatible with only certain companies. In fact, they are essential to ensure the exchange of data between machines, systems and software. Independent, commonly agreed, international standard communication protocols, data formats and interfaces can ensure interoperability across different sectors and countries and they can foster the adoption of Industry 4.0 technologies. (European Parliament Briefing, 2015).

According to the European Parliament, investments are needed to shift towards Industry 4.0. For Germany alone, an estimated €40 billion are needed from now until 2020 and €140 billion annually in Europe. These investments could be very demanding for small and medium enterprises and for this reason national and European plans have been set up.

Another issue concerns data ownership and security. Industry 4.0 requires a lot of data to be collected and shared with partners. It should be clear who owns it and companies must be confident that it isn't used by competitors. Last year the European General Data Protection Regulation (GDPR) came into force substituting the national law. In the full text there are ninety-nine articles setting out the rights of individuals and obligations placed on organizations covered by the regulation. The rights include allowing people to have easier access to the data companies hold about them, a new fines regime and a clear responsibility for organizations to obtain the consent of people they collect information from.

Advanced manufacturing also raises a variety of legal questions including employee supervision, product liability and intellectual property. For example, if an autonomous manufacturing system produces a dangerous product, how should the court determine who in the network is responsible?

Industry 4.0 requires a shift in the way responsibilities are assigned: from manual labour to programming and control of machines. Employees with low skills levels could be replaced unless they are properly trained. By 2020, employment rate labour market in the EU could be short of 825000 ITC professionals (European Parliament Briefing, 2015).

According to the European Union, Industry 4.0 allows major changes to processes, products and business models. Smart factories led to increased flexibility in production. Robot, data transmission and automation make it possible to produce different products in the same production facility. Machines can be configured fast so single and unique products can be produced. Flexibility fosters innovations because prototypes can be made easily and faster than in the past without changes in the production processes.

Digital designs and the virtual modeling of manufacturing equipment and processes decreases the delivery of product time-to-market. Data driven supply chains can speed up the manufacturing process by 120% in terms of time needed to deliver orders and by 70% in time to get products to market (European Commission briefing, 2015).

Industry 4.0 provides room for improving product quality and decrease the chance of error. In the past, product testing was used to detect errors, nowadays it is possible to use sensors to monitor every piece produced. Increased quality control is also used to minimize costs and increase productivity to stay ahead of the competition. In fact, the top 100 European manufacturers save about €160 billion in the costs of scrapping or reworking defective products by eliminating all the defects (European Commission briefing, 2015).

Productivity also increases thanks to Industry 4.0. For instance, most of the machines are run by software that carefully monitors and decreases the chance of error and downtime by an estimated 50%. An advantage to using robot controlled labour is that they can work all day long even when workers are at home, allowing a continuous production while minimizing costs. In Netherlands, Philips produces electric razors employing 128 robots and 9 employees who provide a quality control assistance.

Industry 4.0 allows faster accessibility to products. Companies don't need to outsource jobs to save money by sending it overseas where labour costs less. Thanks to the automation, European companies have the option of keep production in-house by building new factories in Europe.
Industry 4.0 is also changing business models. In the past European companies were competing mainly on costs, nowadays they can compete on the basis of innovation, quality or the ability to produce custom designs. There could be companies that take advantage of data collected by smart products. Consequently, they can base their business models on services rather than products.

European Union Policy

In the 2014 Communication "For a European Industrial Renaissance" the European Commission affirmed that digital technologies are fundamental to improve the European productivity by redefining business models and developing new products and services. According to the document, the European Union has experienced a deep recession and it has been emerging since 2013 when the EU GDP grew by 0.2%. Industry accounts for 80% of the European exports, private research and innovation. For this reason, a strong industrial base is considered the key for the economic recovery and the European competitiveness.
European companies can't compete on low prices because of ambitious social and environmental objectives as well as the shortage of natural and energy resources. Consequently, they should focus on innovation, productivity, resource-efficiency and high value-added. So, innovation and technological improvements are the main sources to foster the European competitiveness. This is why the European Union has projected to spend 3% of the GDP in Research & Development by 2020. To achieve this target, the EU has implemented the Horizon 2020 Program. It is the biggest EU Research and Innovation Program ever with nearly €80 billion of funding available over 7 years (2014 to 2020). The Leadership in Enabling and Industrial Technologies (LEIT) is part of Horizon 2020 and it supports the development of technologies. The program deals with several topics:

1. Nanotechnologies: this science helps address key social challenges such as climate change, reducing carbon emission, developing renewable energies, more efficient use of resources and addressing medical needs of an elder population.
   The Horizon 2020 Programme aims to bridge the gap between nanotechnology research and markets and to contribute to sustainable growth, competitiveness, environment, highly skilled jobs and increased quality of life. The Program foresees the deployment and market introduction of lightweight, multifunctional, economical and environmentally friendly nano-enabled products for different applications, by scaling up laboratory experience to industrial scale and by demonstrating the viability of a variety of manufacturing technologies.
2. Advanced materials: they are particularly important because they may introduce new functionalities and improved properties adding value to existing products and processes. Furthermore, the engineered production of materials by design might allow the development of products and processes under a really sustainable systemic approach.
3. Advanced manufacturing and processing: European companies, particularly SMEs, should renew their production processes. New engineering approaches exploiting nanotechnologies, flexible manufacturing, stimulating working environments, ambient intelligence and clean processing should be employed. This requires more networking, increased flexibility, adapted structures, stronger links between research and innovation, increased added value in products, production and services, and decreased environmental impacts.
4. Biotechnology: the main aim is to exploit the current and future know-how and to boost technological innovation and industrial leadership in those sectors.

A key element of the Program is joining forces with the private sector through public and private partnerships in key industrial domains, so as to leverage further private investments.

Another initiative promoted by the EU is the European Structural and Investment Funds (ESIF). These funds are jointly managed by the European Commission and the EU countries. The purpose of all these funds is to invest in job creation and a sustainable and healthy European economy and environment. They are available to Member States to finance investment in innovation. In 2014-2020, investments in innovation by ESIF will be guided by the concept of 'Smart Specialization', to allow Member States and regions to concentrate investments on their comparative advantages and to encourage the creation of cross-European value chains. The ESIF program mainly focuses on five areas:

1. Research and innovation
2. Digital technologies
3. Supporting the low-carbon economy
4. Sustainable management of natural resources
5. Small businesses

The European structural and investment funds are:

- ❖ European Regional Development Fund (ERDF) which promotes balanced development in the different regions of the EU.
- ❖ European Social Fund (ESF) which supports employment-related projects throughout Europe and invests in Europe's human capital.
- ❖ Cohesion Fund (CF) which funds transport and environment projects in countries where the gross national income (GNI) per inhabitant is less than 90% of the EU average. In 2014-20, these are Bulgaria, Croatia, Cyprus, the Czech Republic, Estonia, Greece, Hungary, Latvia, Lithuania, Malta, Poland, Portugal, Romania, Slovakia and Slovenia.
- ❖ European Agricultural Fund for Rural Development (EAFRD) which focuses on resolving the particular challenges facing EU's rural areas.
- ❖ European Maritime and Fisheries Fund (EMFF) which helps fishermen to adopt sustainable fishing practices and coastal communities to diversify their economies, improving quality of life along European coasts.

Another initiative set up by the European Union is the Competitiveness of Small and Medium Enterprises (COSME) program. It is running from 2014 - 2020 with a planned budget of €2.3 billion. COSME aims at making it easier for companies to access finance in all phases of their lifecycle (i.e. creation, expansion, or business transfer). Thanks to EU support, businesses have easier access to guarantees, loans and equity capital. It also aims to help businesses to access markets in the EU and beyond. It funds the Enterprise Europe Network that helps SMEs to find business and technology partners and to understand EU legislation.

Fifteen national initiatives for digitizing industry have been launched across Europe in recent years. Value chains are becoming more and more European because they develop themselves across several countries. Consequently, digitalization is an issue that should be treated at the European level.

The European Commission has decided to use its policy instruments, financial support, coordination and legislative powers to trigger further investments in all industrial sectors to complement national programs. This includes working with Member States to focus on public-private partnerships pooling resources for advancements in digital technologies and digital industrial platforms, including high-performance cloud infrastructure for science and innovation, as well as large-scale test-beds to accelerate standards setting. It is only at EU level that the pooling of public resources can reach the critical mass needed to attract large private investments. EU level coordination is needed also to address standardization, to examine the regulatory fitness of legislation for the digital single market and to support the sharing of best practices in areas like skills and jobs for the digital change.

Since the first half of 2016, the Commission, together with Member States and industry, has set up a governance framework to mobilize stakeholders, exchange best practices, and support the coordination of EU and national initiatives. The European Platform of national initiatives was launched in March 2017 and it is the main tool to promote coordination. The Platform is essential to flatten digitalization of the industrial sector across Europe. In fact, thanks to it, experiences can be shared, collaboration and joint investments can be made, solutions to regulatory problems be discussed, and means for re-skilling of the workforce be developed. The objectives of the European platform of national initiatives are to jointly build a critical mass of initiatives and investments for digitizing industry, and to ensure the commitment of Member States, Regions and private sector to achieving the Digitizing European Industry goals (European Commission).

The creation of the digital single market in Europe is a prerequisite for attracting investments in digital innovations and for accelerating the growth of companies in the digital economy. To fully exploit the benefits of a digital single market it is essential to transform

the European digital sector into a highly competitive one and to integrate digital innovation among different sectors. The adoption of digital technologies will help companies to expand beyond the EU internal market and will further increase the attractiveness of the European Union for global investments. Digital skills are extremely important, so it's also fundamental to keep the European market open and to develop it further in the digital sphere. The strategy for the digital single market contains all the main levers to improve the digitalization of the industry with actions in areas such as the data economy, the IoT, cloud computing, technical standards, skills and electronic public administration.
High-tech sectors in Europe are well advanced in terms of digital innovations adoption, while most SMEs, mid-cap companies and non-technological sectors are still lagging behind. There are also significant differences among regions in terms of digitization.
Even if it is up to companies to catch up with the new technologies, an effort is urgently needed at EU level to facilitate the coordination of national and regional digitization initiatives in the industry. Today supply chains extend across Europe and digitization places challenges such as standardization, regulatory measures and investment volume, which can only be addressed at the European level. The European commission is working on four main pillars:

1. Cloud computing
2. Information and communication technology
3. E-government
4. IoT

The European cloud computing initiative concerns a plan for the development of a cloud and data infrastructure for scientific and engineering sectors that will provide scientists and engineers with extensive data processing and management capabilities. The infrastructure will provide a virtual environment with open and fully integrated services for archiving, managing, analyzing and re-using research data across borders and at the interdisciplinary level (European Open Science Cloud). The initiative will strengthen Europe's capacity to innovate in all areas and its capacity in terms of digital technology. Thanks to the initiative, Europe will become a world leader in data infrastructures and services and European science, technology and industry will fully exploit the benefits of data-driven science.

As far as information and communication technology, data platforms play a central role. The EU has invested over € 2.7 billion in research, development and innovation activities concerning big data. The goal is to foster the growth of innovative data-driven businesses and to exploit the potentiality of data in any sector. The initiative includes the development of competitive open data platforms and the availability of first-rate data infrastructures in Europe. Key aspects include cyber security solutions to rebuild trust in the data-driven economy and to help businesses to use data in a safe manner. These platforms will encourage the use of data-driven business models by European industries, especially SMEs.
As far as IoT, the Commission is investing in large-scale, demand-oriented pilot projects and flagship initiatives in areas such as smart cities, home automation, driverless cars, wearable technologies and devices, mobile healthcare and the agri-food sector.
The investments focus on cross-sectoral open platforms to speed up innovation by companies and developer communities. They are based on current open service platforms, such as FIWARE which provides a set of Application Programming Interfaces (APIs) and an open source reference implementation that facilitate the development of intelligent applications in multiple vertical sectors.
It is necessary to accelerate the development of common technical standards and interoperable solutions. Interoperability is essential for the spread of IoT and for the continuity of data flow between sectors and regions. The availability of technical standards is essential to prevent consumers from depending on particular providers.
The digitization involves also new regulatory challenges. These depend on data produced by a large number of new intelligent products as well as the growing need for interaction between human beings and smart devices. We need to find the right balance between legitimate business interests and fundamental rights that ensure the protection of personal data and the protection of privacy, as set out in the general data protection regulation.

About 40% of EU workers do not have sufficient digital skills. The need for new multidisciplinary and digital skills, such as the combination of data analysis skills and entrepreneurial or engineering skills, is extremely urgent. The gap between the demand and the availability of workers with digital skills in Europe is increasing.

Digital innovations also offer great possibilities in terms of creating additional jobs in industry, both because they allow new businesses to grow and because they help maintain and restore jobs in the industry. Considering only ICT professionals, over a million jobs have been created over the past four years. On the other hand, rapidly increasing demand suggests that there will be more than 800 000 vacancies by 2020. At the same time, advances in the fields of automation, robotics and intelligent systems are increasingly transforming the nature of work, not only for repetitive tasks but also for complex tasks performed by those who hold administrative or legal functions.

The work in a digitalized economy will also involve the acquisition of new skills and abilities that include greater creativity, communication skills and adaptability. Consequently, the workforce will have to greatly improve its skills at all levels.

As a result of the Digitalizing European Industry initiative, 15 national programs on digitalizing industry have been launched around Europe. While significant progress has been achieved across Europe, investments and funding are still necessary to achieve further improvements.

Several surveys show that firms' size, age and stage of development make a difference on how they adopt technology. For example, smaller firms are more likely to adopt specific technologies than larger ones. Newer companies have a higher rate of adoption compared to the older ones.

There are differences also among National Plans implemented across Europe, not only in terms of programs names. It's not true that the larger the country, the more funding is available by the Government. Governments have invested different amounts of money to assist in the enhancement and development of Industry 4.0. So far, the total amount of funds destined to Industry 4.0 was €200 billion in Germany, €18 billion in Italy and €10 billion in France. Other techniques include tax incentives, fiscal policy designed to attract private investments and support for R&D from public and private companies. However, also these techniques vary from country to country.

Industry 4.0 implementation in Italy

The new strategy puts in place horizontal measures accessible for all enterprises with an objective to boost the investment in new technologies, research and development, and revitalize the competitiveness of Italian companies. The Italian Minister of Economic Development launched the Industria 4.0 National Plan (l4.0) in 2017 to support the technological advances taking place throughout Europe. This plan's purpose is to promote investments in innovation, new technology and development.

This top-down approach includes short and medium term objectives to be achieved in the three-year period, 2017-2020, as well as longer terms. The Government has earmarked €18 billion of financial funds for the purpose of supporting innovative investments.

The plan was first presented in September of 2016 in Milan and it was then launched in February of 2017.

The plan involves measures addressed for enterprises to persuade firms to make investments in new technologies, research and development. Furthermore, many complementary measures have been introduced, such as the Ultra Broadband plan which ensures proper network infrastructures, collaboration for the definition of the IoT standard communication protocols and measures that trigger private investments, mainly venture capital and private equity (European Commission, 2017).

The first group of measures is based on tax incentives. Hyper and super depreciations schemes support companies in their tangible investments in their technological and digital transformation processes. For hyper-depreciation, the investment costs are increased by 150% of their value, while for super-depreciation by 40%. The plan provides for a special tax rate for incomes deriving from the direct or the indirect use of intellectual property rights. In addition, the corporate income tax IRES has been reduced to 24% in 2017.

Innovative Start-ups and SMEs can benefit from tax advantages for equity investment in start-ups. Productivity Wages provide a special tax rate for salary bonuses of 10% for companies achieving an increase in productivity, profitability, efficiency, quality and innovation.

Finally, tax credits enhance an increase in R&D activities by implementing the tax credits at 50% of costs up to the annual ceiling of € 20 million per year (European Commission, 2017).

The second group of measures ensures easy access to finance. 'Nuova Sabatini' provides a contribution for payment of interests from 2.75-3.57% when requesting a bank loan, to invest in machinery, equipment and capital goods to be used in production and digital technologies. The Guarantee Fund for SMEs provides guaranteed loans up to 80% for those who have difficulties to access bank loans.

The third group of measures is related to the development of skills required by new technologies and innovative processes. The Digital Innovation Hubs can be considered a contact point between companies, investors and research institutions, supporting and facilitating innovative investment plans. L4.0 Competence Centres provide training, live demos, presentation of best practices, technical advisory services for SMEs, launching and accelerating innovative projects and technological development. In addition, educational programs have been launched in order to sharpen employee skills, such as "Scuola Digitale" (a national program modernizing and restructuring the school system), and "Alternanza Scuola Lavoro" which is an innovative learning experience that fosters collaboration between schools and workplaces. Students are required to work in a company for 3 weeks per year during the last years of school.

The measures are addressed mainly to SMEs as they're the cornerstone of the Italian industrial landscape. However, they are addressed to firms in every sector, from automation to food.

Since the implementation of I4.0 is at an early stage, we can only rely on very little data. However, the first effect was demonstrated in the manufacturing industry by an increasing trend of domestic orders. More specifically, UCIMA (Unione Costruttori Italiani Macchine Automatiche per il Confezionamento e l'Imballaggio), showed an increase of 22.2% in the first quarter of 2017, followed by an increase of 28.5% in the second quarter, confirming the tendency to acquire new machinery and new technologies as a result of implemented financial tools.

In the long term, new technologies and innovative processes are expected to increase flexibility in production, contribute to faster development from the stage of prototyping to production, improved productivity as a result of lower set-up time and reduced downtimes. Thanks to real time production monitoring systems and the raw data it provides, manufacturers are reaching higher competitiveness of the products, improved quality and additional functionalities enabled by IoT.

Italy has recently signed a trilateral cooperation with France and Germany to strengthen the digitalization process. This cooperation brings together industry, scientists and political experts from the three countries working on three core themes: standardization, engagement of SMEs and testbeds.

In 2017, the Economic department of Padua University launched a project to carry on a first map of degree of Industry 4.0 technological investments, understanding advantages and results achieved in the introduction of such technologies and exploring reasons preventing firms from adopting new technologies. They focused on specific made in Italy industries such as fashion, home furnishing and mechanics. They made a research on a sample of 5.421 manufacturing firms established basically in the north of Italy, including Emilia Romagna.

19% of the companies interviewed, had adopted one of the 7 technologies included in Industry 4.0 scenario (robots, laser cutting, big data - cloud, additive manufacturing, IoT, 3d scanner and augmented reality). The other 81% of respondents were non-adopters. Data showed that not only big firms were investing, there was a mix of companies, composed of large and small ones (1 million of turnover or less). According to these results, these firms had adopted one or few technologies, that were more coherent with the industry's characteristics. A common thought is "the more technologies companies invest in, the better they'll perform". According to the results, this is not true. It's not a matter of number of technologies used but more importantly, the quality, loyalty and service they provide to their customers. More than 65% of non-adopters explained that they were not interested in new technology because they feel that it won't affect the way they do business. It was more a strategical and cultural idea. The 21% of non-adopters gave a different reason. They explained that their business model relied more on traditions passed on from their ancestors and that their clients were attracted to that traditional way of doing business and handling the craftsmanship of creating "homemade" goods. As artisans of family owned businesses, and smalls firms they thought that this new revolution was something interesting only for bigger firms. Probably, a problem is the name of the plan: Industry 4.0.

Data showed also a statistic correlation between firms that invested in ITC and firms that are investing in Industry 4.0.

Companies are not really buying technologies, but they are developing Industry 4.0 projects. Three out of four firms have customized what they have bought. They had to update themselves in terms of software but also hardware, and they had to integrate the new technologies with the already existing infrastructure. This explains that investing in industry 4.0 is much more complex than just buying something: firms need to pay consultants to integrate systems. The suppliers of machines that bring technologies into firms are among the most important partners, as well as consultants, technology providers and universities.

Based on the results, investing in industry 4.0 is a market driven investment. Companies are not only investing to be more efficient, but also supporting international competitiveness, to provide a better service for customers, to exploit new market opportunities and to increase the variety. In addition, Industry 4.0 allows the reshoring process, allowing us to rebalance our economy and bring the local employment rate up. The idea is to bring the production and manufacturing back to Italy.

Companies are running into three main difficulties:

1. Lack of internal competences and integration among technologies or difficulties finding the right partners and consequently the time of implementation increases
2. Lack of infrastructures that support digitalization such as the broadband
3. Limited financial resources

There is a huge debate about the consequences of Industry 4.0 on employment rate. Made in Italy story teaches us that it's not a matter of substitution. Just a very small fraction of firms (i.e. 2%*)* affirmed to have decreased employment, but the 40% said that they have increased the labour force. This suggests the idea of complementarity between technologies and humans.

Industry 4.0 implementation in Germany

"Industrie 4.0" (I40) is a national strategic initiative from the German government to drive digital manufacturing forward by increasing digitization and the interconnection of products, value chains and business models. It also aims to support research, networking of industry partners and standardization. I40 is pursued over a 10-15-year period and it is based on the German government's High Tech 2020 Strategy.

Germany spends almost 3% of GDP on research and development, so it has already achieved the target that EU set itself for 2020. Two-thirds of the overall expenditure of roughly €90 billion has come from industry. Germany employs government funding as well as companies' investments to finance research.
The High-Tech Strategy is the Federal Government's key instrument in this context and it is attracting increasing international attention. It was presented by the Federal Government in 2010. The main difference compared to the past initiatives is that it is mission oriented. It means it is oriented to major priority areas, rather than specific technologies and research programs. It leads to a major cooperation between different ministries as well as a major awareness and transparency among citizens. The six involved areas are:

1. Digital economy and society
2. Sustainable economy and its energy
3. Innovative workplace
4. Healthy living
5. Intelligent mobility
6. Civil security

Industry 4.0 plan is conceived within the first area of intervention "digital economy and society", together with smart services and data, cloud computing, digital networking, digital science, digital education and digital life entertainments.
Close cooperation between science and industry in research and development is one of the traditional strengths of the German innovation system. The capabilities of innovation centre no longer depend solely on close integration within international knowledge networks; they also depend on integration in international and interdisciplinary, knowledge networks. Knowledge grows through sharing at the regional, national and international levels. In the framework of the High-Tech Strategy, over the past few years many cooperative efforts, clusters and networks have been established in which many partners coming from the areas of science, industry and society collaborate. (BMBF, 2014).
Universities, especially those of applied science, work close to businesses to carry out researchers which are application and solution oriented. Education and research have enjoyed high priority under Angela Merkel's chancellorship.
In this context there is the need to experiment and try out new ideas.

The country has established the Research Campus project, a new form of cooperation between companies and researchers. The Leichtbau-Campus in Wolfsburg is developing technologies for the large-scale production of hybrid lightweight components for the motor industry. Funds are provided for this development at a very early stage because resource-conserving lightweight construction has clear advantages, regardless of the type of drive technology used in future.

The Federal Government supports small and medium-sized enterprises (SMEs) with a coordinated, effective system of innovation funds. SMEs that lack their own research departments can work together with research institutions and major companies and develop innovations together.

A number of measures are designed to reinforce the competencies of innovative SMEs. The "SME-Digital" ("Mittelstand-Digital") initiative is promoting greater use of ICT and eBusiness among SMEs, especially among crafts companies.

The "go-Inno" initiative is supporting SMEs in improving their innovation management and enhancing their resource and material efficiency (BMBF, 2014).

The I40 initiative was launched in 2011 by the Communication Promoters Group of the Industry-Science Research Alliance (FU). It was convened and organized by BMBF (Ministry of Education and Research) and adopted through the High-Tech Strategy 2020 Action Plan. I40 has become institutionalized with the Platform Industrie 4.0 (Platform I40) that now serves as a central point of contact for policy-makers. The Platform "Industrie 4.0" is one of the world's largest Industry 4.0 networks. It brings together companies, business associations, the academic community, trade unions and policymakers to enable all stakeholders to implement this mission at various levels. Its main aim is to coordinate the digital transformation process of the industrial sector. Six working groups are focusing on central challenges and they are producing recommendations for action, guidelines, solutions, discussion papers and policy framework. They are focusing on future aspects of standardization, security of connected systems, legal framework, technology and application scenarios, work, training as well as digital business models. The platform offers and coordinates information and networking opportunities to introduce Industry 4.0 solutions to companies throughout Germany. The Platform Industrie 4.0's online map provides more than 350 use cases and an overview of testbeds to showcase where Industry

4.0 innovations are successfully implemented. Additionally, the Compass Industrie 4.0 gives an overview of nationwide support structures.
BMBF and BMWI (Ministry for Economic Affairs and Energy) have jointly allocated €200 million in funds. This public investment is complemented by in-kind contributions by industry.
The objective of the I40 platform is to secure and develop Germany's leading position in industrial manufacturing and to promote digital structural change and a framework to achieve it. It further aims to develop a consistent overall understanding of Industry 4.0 through dialogue with stakeholders, to draw up recommendations for action and to demonstrate how industrial manufacturing can be digitized.

"We must (...) deal quickly with the fusion of the online world and the world of industrial production. In Germany, we call it Industrie 4.0."

Angela Merkel, German Chancellor

Businesses, science and politics are working together to make Industry 4.0 a reality.
I40 targets large corporations, entrepreneurs and in particular SMEs in industrial sectors. It aims to realize a restructuring of manufacturing processes, transforming analogue in centralize work flows into digitals and decentralized production processes. Comprehensive digitalization would decrease production costs, be resource efficient and cost oriented. At the same time new business models, innovative products and new services will be created.
Machinery and plant engineering along with the electronic industry are the strongest industries in Germany. Internet driven, self-controlling and sensor aided production systems will shape the future of the machines.
GE Global Research Europe is developing software and methods for analyzing digital industrial application data. In the future the production process will involve machines equipped with sensors that collect data about location, status, work time and so on. When reviewing and analyzing records, this data will lead to much more efficiency of processes and to identify sources of errors quickly and this will allow to save even more costs. Men, machines and products will communicate to each other in real time allowing for a self-organizing production process. The product will carry crucial information by itself.

According to Mrs. Brigitte Zypries, who is the Federal Ministry for Economic Affairs and Energy, Germany has excellent conditions for the development of I40 because of its highly developed industrial landscape and the industry which exists in the country and not in others. As underlined before, the federal government supports these developments with funds. Examples can be found in the aviation, space and maritime industries where there are many specific programs to promote the development of I40.

Germany Trade & Invest is the economic development agency of the Federal Republic of Germany. People working there are the first point of contact for International companies interested in opportunities of entering the German market. They help companies to adopt the right strategies, they give legal advice and provide direction and guidance for financing and funding opportunities in the German market.

The government has projected investments of 40€ billion per year for I40 applications by 2020 and according to statistics about 83% of German companies will fully digitalize their value chain by 2021. Exports expect to increase efficiency by 18% and to reduce costs by 13%.

Industry financing is essential for running I40 and its platform. Industry partners provide in-kind and financial contributions for the research they participate in. SMEs can get up to 60% in public financing, but typically they have a share of around 50%. Larger companies receive below 50% in public funding according to EU funding rules.

SMEs would typically account for half of the project costs and larger companies for slightly more than that. In order to receive public funding in research projects, participants have to calculate a budget for the planned work. The ministries calculate if budgets and activities are realistic and they also follow up on the financing of projects, in particular by assessing if the beneficiaries have invested their share of the money.

There is no clear or accepted definition for which activities and research qualify as industry 4.0 because the distinction for what falls under industry 4.0's reach is somehow ambiguous. The verification of the beneficiaries' investment is made after the end of the project. It is therefore considered difficult by BMBF and BMWI to compile data and quantify figures on how much money is spent by private sector sources.

According to a 2018 study carried out by the business consultancy Staufen AG and Staufen Digital Neonex GmbH, the majority of the German manufacturing companies have already

implemented Industry 4.0 technologies. Less than one out of ten companies continues to reject this trend.
These consultants surveyed a total of 450 companies in Germany on the topic of Industry 4.0. The survey was conducted in mid-2018. The majority of the companies come from the mechanical and plant engineering, electrical engineering and automotive industries. The Digital Transformation Monitor underlines the fact that industry segregation has been reduced and that the research agenda has been transformed into practice.

Industry of the Future implementation in France

"Industrie du Futur" (Industry of the Future (IdF)) program was launched by the French government in April of 2015. It aims to support companies to deploy digital technologies, to transform firms and business models as well as to renew production practices. IdF targets selected priority markets and it includes five pillars:

1. Cutting-edge technologies: by supporting companies with research funding, subsidies and loans and by developing a network of platforms for pooling and testing new technologies.
2. Business transformation
3. Training to improve workers skills by joining efforts with unions to develop improved future training programs.
4. International cooperation on standards and alliances. A bilateral approach is taken, in particular with Germany (Industrie 4.0) through cooperation on standardization and technology projects. There is also an emphasis on boosting French interest at the European level by 2020.
5. Promotion of IdF through the launch of flagship projects, the organization of a major industry trade fair and the "Creative France Industry" brand

It makes up for the second phase of the French strategy "La Nouvelle France Industrielle" (New Industrial France (NFI)), which was launched by the government in September of 2013. IdF has launched the platform "Alliance Industrie du Futur" (Industry of the Future Alliance (IdFA)) in order to secure coordination and dialogue and bring together industry and digital technology stakeholders from public and private sectors.

This new policy was carried out because the country was suffering from underinvestment and problems in developing competitive digital industries. Consequently, the government has promoted several initiatives to help companies introduce new innovative digital technologies. It has invested around €47 billion in the strategic program "Investissements d'Avenir" (Invest for the Future) which supports innovative projects through a series of proposals on fundamental research, innovation, technology transfer and implementation. According to the program, 22 billion euros are destined to higher education and research. The Industry for the Future follows a bottom-up approach. The ministry provides overall public funding support through subsidies and loans to industry and research projects. However, the main source of funding comes from private investments in R&D and production. The funding model behind IdF combines private and public funding, so it's a mixed model like the German one, differently from Italy where funding is only public. €10 billion have been made available from public sources for IdF, which includes some additional funding from 2017 onwards through the third IftF program. The development of technological offerings is supported by €550 million on calls for projects and €100 million for IdF. In addition, €150 million have been offered for this purpose since 2017. In order to support business transformation, €4.2 billion is available in the form of loans for SMEs and mid-tier firms to invest in production. Meanwhile, €5 billion is available through tax aid for investments for the 2014-2020 period. Lastly, €100 million have been provided for staff training since 2017. Because of the regional authorities' competences on economic development, some regions provide additional local funding to companies that invest in technologies (Digital Transformation Monitor, 2017).
The French initiative takes a market-based approach providing loans to companies participating in the program. The French IdF combines a broad range of funding instruments, such as loans and tax incentives with private investments in R&D.
It is addressed to local players, such as SMEs and mid-tier companies, but also technology providers, academia and public bodies. IdF focuses on new and emerging technologies, such as additive manufacturing, IoT, new materials, high-performance computing, smart objects and artificial intelligence.
It equally entails an attempt to promote a convergence of industry and services, thereby providing coverage of the full process from design, production and logistics to after-sale services.

One of the main difficulties met during the initial phase of NFI was the lack of a common structure and network for collaboration on digital transformation, which made it difficult to dialogue and coordinate.
This problem was solved with the implementation of the Idf and the platform.
The second barrier consists on the current gap between industry needs and workers skills. While a common ground and understanding exists regarding the potential of digital transformation and advanced manufacturing practices, there is some uncertainty about future work roles and how work and shop-floor processes should be re-organized. IdF has therefore made skill-sets and training a core component and it has strengthened the links between social partners and the alliance (Digital Transformation Monitor, 2017).
Finally, there are also issues concerning evaluations under IdF. Beneficiaries are expected to deliver input on indicators on a monthly basis. However, beneficiaries and stakeholders have found it difficult due to the complexity and wideness of digital transformation, which has complicated the assessment of progress.
In terms of the broader NFI strategy, the government is expected to help the French industry to adapt to key emerging challenges, creating approximately 480.000 new jobs in 10 years, and to generate €45.5 billion in added value, nearly 40 % of which will come from exports. As of 2017, IdF has supported almost 8700 companies by providing diagnosis for modernization production tools and loans.

Smart Manufacturing implementation in the USA

Manufacturing plays an important role in the USA economy. Advanced manufacturing includes both new production processes and new products enabled by innovations. Technologies are fundamental as they improve productivity, create new products and new industries.
During the last recession, from 1990s to 2008, US manufacturing employment decreased, specifically in the areas of production, communication and computer industries.
On January 2014, president Obama gave a speech at North Carolina State University where he talked about a new phase of the manufacturing innovation. The policy initiative name was "National Network for Manufacturing Innovation" (NNMI). It is a network of fourteen research institutes which should foster design, development and commerciali-

zation of new manufacturing technologies. It is made up of both private and public companies, universities, government agencies and non-profit organizations. It is administered by the interagency Advanced Manufacturing National Program Office, which works together with the Department of Defense, the Department of Energy, NASA, the National Science Foundation and the Department of Education, Agriculture, Health and Human Services.

Innovation has always been a typical characteristics of the American industry. Private investments in manufacturing-based technologies have decreased in recent years as investors have focused on the rapid return on investments possible through software-based start-ups. Manufacturing leadership in emerging markets, exports, and trade not only requires investments in advanced technologies, but also the ability to effectively leverage new technologies and platforms across industrial sectors (US government, 2018). For this reasons, the current administration has taken strong policies. Based on a report written in October 2018 by the US government, manufacturing employment declined by 20 percent, from 14.2 million to 11.3 million, in the four years between 2006 and 2010. Although manufacturing employment rate remains considerably below its 2006 level, manufacturing jobs still account for 8.5 percent of the workforce, and nearly 350,000 manufacturing jobs have been created since President Trump took office.

A 4 year-period plan was developed by the National Science and Technology Council, Committee on Technology, Subcommittee on Advanced Manufacturing. Its main aim is to create an American leadership in advanced manufacturing across industrial sectors to ensure national security and economic prosperity**.** This is achieved by pursuing three goals:

1. Develop and transition new manufacturing technologies;
2. Educate, train, and connect the manufacturing workforce;
3. Expand the capabilities of the domestic manufacturing supply chain.

As far as the first point, the main objective of the future digital and smart manufacturing will be the integration from design to part production. The current smart manufacturing is not 100% reliable because nowadays many fixes are carried out to solve problems and these represent the most of the engineering costs. Advancements will allow the highly integrated design and manufacturing of complex products in less time and at lower cost, while increasing the time-to-market. In order to achieve this goal, the following activities have been planned for the next four years (US government, 2018):

- ❖ Facilitate a digital transformation in the manufacturing sector by enabling the application of big data analytics and advanced sensing and control technologies to a host of manufacturing activities.
- ❖ Prioritize support for real-time modeling and simulation of production machines, processes, and systems to predict and improve product performance and reliability.
- ❖ Study and research historical design, production, and performance data to reveal the implicit product and process know-how of the expert designers who created them.
- ❖ Develop the standards that will enable seamless integration between smart manufacturing components and platforms.

Collaborative smart robots are very useful tools that contribute to the reduction of manufacturing costs related to human mental and physical effort. On the other side they improve quality by reducing errors while increasing productivity. With the constant changes and advancements in technology, it is important to keep up with trends and upgrades. In fact, even robots need maintenance and upgrades as some of them move without awareness of their environments, making their vicinities hazardous to humans and precluding their use as assistants to human workers or as cobot. A cobot is a robot that interacts with humans because it is not designed to work in an autonomous way. The future goal is to improve and develop human-robot interaction, adaption, learning, manipulation, autonomy, mobility, agility, dexterity, and perception. They should be also able to predict human actions in order to improve human safety. To achieve this goal, the US government has committed itself to promote and develop new technologies to foster the adoption of robots and cobots in manufacturing environments.

There is a need to develop and implement cross training interaction between robots and humans. To achieve this objective, the following actions will be undertaken (US government, 2018):

- ❖ Develop new standards for artificial intelligence and identify best practices to provide consistent availability, accessibility, and utility of manufacturing data within and across industries, while maintaining data security and respecting intellectual property rights.

- ❖ Prioritize R&D to develop new approaches to data access, confidentiality, encryption, and risk assessment for U.S. manufacturers.

As the implementation of artificial intelligence grows, the risk for malicious attacks will increase. Data could be stolen, used for inappropriate scopes or changed. For these reasons, strengthening cybersecurity has become a national need. New technologies will be implemented such as blockchain for security of sensitive manufacturing information, or Artificial Intelligence to threat detection and handling.

Advanced materials are essential to economic security and human well-being, with applications in industries aimed at addressing challenges in clean energy, national security, and human welfare. It can take 20 or more years to move a material after initial discovery to the market. Accelerating the pace of discovery and deployment of advanced material systems will therefore be crucial to achieving global competitiveness in the 21st century. Since the launch of MGI in 2011, the US Federal government has invested over $250 million in new R&D and innovation infrastructure. It hopes to continue investing future initiatives like this one and to help promote them. The government wants also to develop standards for the additive manufacturing which is an in-house production, tooling and prototyping of products in any industry which allows the production of any object by building it one layer at a time. In fact, it is needed to ensure the reliability and the repeatability of production parts.

Critical materials for this process are those that have exceptional properties which are difficult to replicate. Additive manufacturing uses any number of materials, from polymers, metals, ceramics and foams, gels, and even biomaterials but there is a shortage problem with these materials and so the government has invested funds in material research. In particular, it aims to:

- ❖ Develop advance cost-effective processing and separation technologies to reduce the cost of production.
- ❖ Reduce reliance on critical materials by investigating substitutes and material alternatives where possible, and develop the means to recycle critical elements by innovating manufacturing processes.

For what food industry is concerned, the technical priorities are processing, testing, traceability in food safety, production and supply chain for food security and improved cost and functionality of bio-based products (US government, 2018). In particular, funds will be implemented to facilitate and transfer smart and digital manufacturing concepts to food manufacturing, including the use of digital imaging, automation, advanced detection, and digital threads to improve supply chain integrity.

US Food and beverage market has changed over the last years. It's more dynamic and customers require more customization and personalization. Technologies help to satisfy these customer requirements. Coca Cola launched the "Share-a-Coke" initiative. It involves printing a different personal name for each can or bottle. So, technology has made mass personalization a reality. Furthermore, customers pay much more attention to food safety and technology and so now, companies are focusing more on having the right tools and connections to food safety and sanitary precautions.

Another big challenge for the US food industry is linked to robotic arms. Robots employed in this sector, need arms able to grip irregular shaped items because here variables are much more unpredictable than in manufacturing industry.

As far as the second pillar, workers should be prepared in science, technology, engineering and mathematics (STEM). Appropriate education is required, from elementary to high schools. The Trump administration has allowed connections between students and businesses, it has focused on innovation and entrepreneurship and it has introduced computer science principles.

Advanced manufacturing depends heavily on private investments, but also the government supports it through direct investments in early stage R&D, policies which limit red tape, protect property rights and foster the deployment of innovations within the American territory. It also provides the opportunity to take part in world-class laboratories and research facilities. In particular, federal agencies play key roles in fostering the growth of advanced manufacturing through investments in R&D, in education and workforce development (US government, 2018).

In order to achieve the third goal (i.e. expanding the capabilities of the domestic manufacturing supply chain), the government has planned several objectives:

- ❖ Increase the role of small and medium-sized manufacturers in advanced manufacturing. The government has committed itself to create connections with sources of technologies, technical infrastructure and specialized knowledge through vendors, universities, Federal laboratories and Manufacturing USA institutes. SMMs also need trusted advisors who can provide appropriate advice on the real possibilities of new technologies.

- Encourage ecosystems of manufacturing innovation. In the past, R&D consortia around technology and capability have been formed by the Federal government. Anyway they failed because they weren't industry focused and consequently they didn't receive funding by industry. For this reason, the current plan provides for expanding the creation and utilization of manufacturing collaborations and consortia for both technology and economic development as well as creating additional public-private partnerships focused on technologies critical to America's future competitiveness.
- Strengthen the defence manufacturing base.
- Strengthen advanced manufacturing for rural communities.

Made in China 2025

China's manufacturing sector has been challenged for some time by rising labour costs, environmental and resource difficulties and a slowdown in terms of exports. For these reasons, the "Made in China 2025" initiative was launched by the Chinese government in 2015. The main objective of this initiative is to incentivize companies to upgrade in order to become more competitive, efficient and productive through mandates, loans, subsidies and other financial methods. To achieve these objectives, the initiative has set up key milestones in four steps. The first step goes to 2020, the second one goes to 2025, the third to 2035 and the fourth to 2049.

"We will implement the Made in China 2025 strategy, seek innovation-driven development, apply smart technologies, strengthen foundations, pursue green development, and redouble our efforts to upgrade China from a manufacturer of quantity to one of quality."

Premier Li Keqiang

This initiative has been compared with the German "Industrie 4.0", in fact part of that plan, known as Internet Plus, aims to integrate mobile internet, cloud computing, big data, and

the Internet of Things (IoT) with modern manufacturing to encourage the healthy development of e-commerce, industrial networks, internet banking and to help internet companies to increase their international presence (Liu, 2016).
Actually, Chinese industry currently still uses tools and systems of the second industrial revolution and it has only begun to embrace the third revolution. Chinese enterprises are only starting to use technologies which are already widespread in industrial countries. Technologies employed by Chinese factories are traditional industrial robots, industry software and computerized machine tools, as well as cutting-edge production technologies, such as wireless sensor networks, intelligent robots and integrated software processes (MERICS, 2016).
The plan involves substituting China's reliance on foreign technology imports with its own innovations and creating Chinese companies that can compete both domestically and globally. So, there is a strong emphasis on its domestic manufacturing process to increase production of both components and final products.
With a focus on quality, the investment is towards technological innovation and smart manufacturing in areas such as machine learning. Smart manufacturing involves combining internet with wireless sensors and robotics to improve manufacturing efficiency, quality, and productivity. If successful, China would move up the value-added chain, repositioning itself from a low-cost manufacturer to a direct competitor to nations like South Korea, Japan, and Germany (Institute for Security & Development Policy, 2018).
MIC 2025 comes from the 2006 initiative "Strategic Emerging Industries" (SEI) which has a smaller aim. In fact, it focuses on strengthening the position of strategic emerging industries such as renewables and alternative fuels and those industries that make up the Chinese Economy. MIC 2025 is broader in scope as it addresses the entire manufacturing process rather than only technical innovations, promoting traditional industries and services and introducing "specific measures for innovation, quality, intelligent manufacturing, and green production". (Institute for Security & Development Policy, 2018).
The new policy involves different industries: advanced information technology, automated machine tools and robotics, aerospace and aeronautical equipment, ocean engineering equipment and high-tech shipping, modern rail transport equipment, energy saving and new energy vehicles, power equipment, new materials, medicine and medical devices and agricultural equipment. One of the aims is also to improve the brand awareness

of companies. For example, in the agriculture sector, the goal is to establish up to three recognizable brands and up to five internationally competitive companies.

China is making changes to its regulatory system and it is introducing standards for key industries while setting a policy direction to pursue innovation and development. These standards potentially restrict foreign competition in the country. Testing and certifications will be introduced to improve the quality of products to meet international standards in all key industries, from medical patents to fuel consumption.

State-owned banks are distributing subsidies, low-interest loans, and bonds, especially for small and medium-sized enterprises. Various agencies and funds also offer direct financial support. For example, $3 billion is available from the Advanced Manufacturing Fund to upgrade technology in key industries, while the National Integrated Circuit Fund has access to $21 billion. Importantly, funding is linked to the use of indigenous IP to push companies to replace foreign IP.

The government has also introduced various targets for companies, including an increase in research and development as a percentage of sales from 0.95 percent to 1.68 percent, a 7.5 percent labour productivity increase by 2020, and a 35 percent decline in energy and water consumption per unit of added value by 2025.

This initiative is difficult to implement because China fells pressure from two sides. At one side there are the most industrialized economies such as Germany and Japan and at the other side there are the low cost one, such as India and Brazil. Specifically, high tech industries, such as Germany and USA have expressed their hostility to the initiative. In fact, their fear is to lose their competitiveness because MIC 2025 provides preferential access to credit to local companies to foster their research and development capabilities.

Another limitation is that few companies are prepared to such technological transformation. As a consequence, few selected companies will be able to meet the government's targets.

CHAPTER II

Italian agribusiness sector

Food and drink are two of the most important industries worldwide. Based on the statistical archive of active enterprises (ASIA), in Italy the agri-food beverage and tobacco sectors account for over 71.000 firms and 464.000 employees (ISTAT 2008).

Food and wine are now considered complex and multidimensional consumer goods associated with hedonistic and cultural aspects. They are no longer be perceived just as basic necessities in economically and socially developed countries. All this makes the demand for food products relatively less sensitive to price and more flexible compared to the income, generating new opportunities for the agribusiness.

Summary of the agribusiness sector

Turnover	**137 billion +3,8% compared to 2016**
Companies	58.000
Employees	385.000
Export	32,1 billion
Import	22,1 billion

Source: Fondimpresa (2018), Report conclusivo di monitoraggio 2017/2018 indagine di follow-up

2017 was the year in which the Italian economy pushed towards global expansion but, compared to other European economies, it met more difficulties because of the collateral effects of a crisis that in Italy has been harder and deeper than elsewhere. In this year real GDP growth was around 1,5%.

In all, this is a positive figure that comes after a long period of recession, from the second half of 2008 to the end of 2014. In reality, Italy experienced two periods of real economic crisis: one in 2009 and again in the two-year period 2012-2013. These periods were then followed by a slow recovery in the following two years.

In 2017 the Italian economic situation was still very difficult because the level of real GDP was five points below the pre-crisis level and it was very different from that of the other European countries as a whole. Most had already started the recovery process in 2014.

A significant consequence of these different trends is that Italy has lost its position also in terms of GDP per capita.
In this context, the agribusiness sector showed a remarkable resilience that allowed it to have good performance despite the crisis. The added value created by the agriculture, forestry and fishing sectors remained stable, both in terms of impact on the total economic sector (i.e. 2.1%), and in real terms (that is the added value at constant values).
Furthermore, in 2017 the food industry detached from the general negative trend, registering an increase in real added value by 6 points compared to the pre-crisis level.
The primary role of the agri-food Industry and its effect on the Italian economy can be better understood by analyzing the value of food products in the final Italian consumer market. This value was worth 171 billion euros in 2017 according to Italy's Gross Domestic Product (GPD) value, 10.6% of the country's total value for that year. This figure does not include the value of extra-domestic consumption (i.e. purchases made by catering services). If included, these estimates rise to € 219.5 billion and the impact on GDP rises to 13.5%.

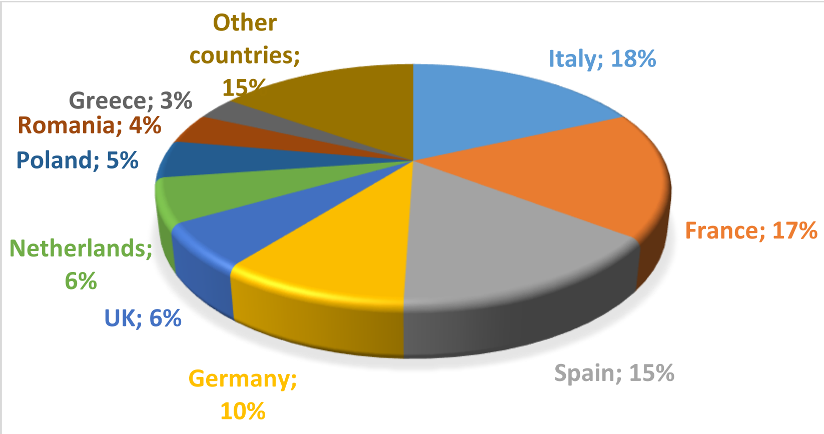
Value of food products in the final market

	PURCHASE PRICES	
	MILLION EUROS	SHARE %
GDP	1.621.827	100
Food, drink and tobacco products	134.963	8,3
Agricultural, forestry and fishing products	36.247	2,2
Agricultural and hunting products	31.689	2,0
Forestry products and related services	890	0,1
Fish and other fishing products; aquaculture products and fishing support services	3.668	0,2
Catering services	48.266	3,0
Total agri-food products	171.211	10,6
Total food products and restaurant services	219.476	13,5

Source: Ismea (2018), Rapporto sulla competitività dell'agroalimentare italiano

The impact of the added value of agriculture, forestry and fishing on GDP, (i.e., 2.2%), confirms Italy's greater "agricultural" vocation. In fact, the European average is equal to 1.5% and the closest competitor is France where the added value on GDP is 1.7%.
The added value of Italian agriculture represents 18% (31,5 billion) of the total EU value. As a consequence, at the European level, Italy is in first place, followed by France (28.8 billion) and Spain (26.4 billion). The estimate refers only to agriculture; forestry and fishing are not included. Data has been elaborated by Eurostat, Economic Accounts of Agriculture (CEA).

Agricultural added value between 2015 and 2017



Source: ISMEA (2018), Rapporto sulla competitività dell'agroalimentare italiano

Yet, economic results in real terms (i.e. without considering monetary trends) in Italy appear particularly disappointing compared to EU partners. In fact, the agricultural added value in the 2016-2017 period decreased by 0.4% compared to the two-year period 2012-2013 whereas it grew by 9,4% in the 15 EU and by 10,6% in 28 EU. Specifically, Spain achieved + 19% and France + 6.4% in the same period.
2017 was a particularly bad year for Mediterranean agriculture. In Italy and Spain, agricultural production by volume decreased compared to the previous years, because of unfavourable weather conditions. There was a drop in the volumes produced in almost all areas of the country. The most penalized regions were those at the Center, where production fell by 5.7%, and those in the North-east (-3.4%); significant negative performances also characterized the Islands (-2.7%) and the North-west (-1.9%). Only in the South of Italy, the production increased by 0.6% compared to 2016.
The sectors which suffered the most were cereals (-13,5%), wines (-8,8%), fodder, vegetables and potatoes, fruit and citrus fruits (-11,6%). The production of olive oil was better

compared to the previous year (+47,3%), which was the worst year in the last decade as regards the volumes produced. Also milk production achieved a great recovery compared to 2016, in fact national production at current prices increased by 7% compared to the previous year. One third of production is concentrated in Lombardy region (1.7 billion euros), followed by Emilia-Romagna. The majority of sheep and goat milk production is concentrated in Sardinia and Lazio regions.

The animal meat sector registered a 6.3% growth in production at current prices in 2017. The most important regions are those in the North: Lombardy, Veneto, Emilia-Romagna and Piedmont. These four regions produced about two-thirds of animal meat in 2017.

The only component of agricultural output that has increased at constant prices is represented by secondary activities, which increased by 3.5% in volume and by 5.0% at current values.

The negative results in terms of volumes were offset by a growth in prices that was generalized in many EU countries. In Italy the value of production increased by 2.5% at current values but it decreased by 2.9% at constant prices. Thanks to the limited growth of current costs for intermediate inputs during 2017 (+1.7% compared to 2016), the Italian agricultural added value at current prices increased by 3.2%.

Unlike agriculture, the production of the Italian food industry obtained better results than the 28 EU average. The Italian food, beverage and tobacco sector represents around 10% of the 28 EU's added value, like Spain and behind France (which is the leading country together with Germany).

Employment and investments

The employment trend in agriculture over the last five years has been positive and in line with the overall recovery of the employment levels in Italy. The number of employees increased by 3.0% between 2013 and 2017.

The contribution of the primary sector to the increase in the employment rate was particularly significant in the two-year period 2015-2016. In 2017 the employment level decreased by 0.8% because of the lower production which led to a lower need for workers. At the end of 2017, there were 919 thousand workers employed in the agriculture, forestry and fishing fields, accounting for 3.7% of the Italian employment rate.

Significant public funds have been provided which have been exploited mainly in the three-years-period 2010-2012.
Ismea (Institute of Services for the Agricultural Food Market which is a public economic institution that carries out information, insurance and financial services) has estimated that investments made by farms in the 2007-2013 rural development planning period represented 13% of the total investments made in the sector and, especially in the South. They included support for investments linked to modernization, innovation, start-ups and diversification. Nowadays agricultural companies can benefit from the 2014-2020 rural development plan. Since 2015 there has been a limited use of investments which also extended to the agricultural sector.
In 2017, this growth was strengthened, in fact investments in agriculture, forestry and fishing sectors, increased by 1.7%. However, it is important to consider that agricultural real terms investments were 30% lower than those observed in 2007. The propensity to invest, that is the incidence of investments expressed at current values on the added value, felt to 27% in Italy in 2017.
With regards to the food industry, the most up-to-date available data on investments refer to 2015. There has been a contraction between 2007 and 2015, but it was lower compared to agriculture and to the other economic sectors. Credits and loans provided to the sector grew by 6.2% from 2013 to 2017.

Food consumption

The expenditure for food and drink products calculated by Istat was worth 160.1 billion in 2017 and it represented 15.1% of the total expenditure. This data comes from Istat national accounting estimates and it includes both domestic and extra-domestic consumption.
In 2017, the total food expenditure both at home and outside home grew by 2.3%, while the expenditure of Italians for all consumer goods grew by 2.6%. However, positive changes in food consumption had already occurred in 2015 (+ 2.3% compared to the previous year) and in 2016 (+ 1.1%).

Nielsen Holdings Inc. (which is an American information, data and measurement company with headquarters in New York City, USA) has studied the Italian consumer behaviors and it has identified five profiles: Mainstream, Traditional shopper, Silver shopper, Low price and Golden shopper

Consumer profiles were defined by analyzing the shopping cart, so the actual buying behavior and not just statements. In particular, Traditional consumers (4 million families) refer to mature families with below-average income. Silver consumers (5.9 million families) are households with above average income; they are located in the North. Mainstream consumers (6.3 million) are families with young children and an average income. Low Price consumers (4.3 million) are slightly younger families with an average spending capacity and Golden consumers (4.3 million), are middle-aged families without children.

To each consumer profile corresponds a specific approach to food spending. For example, Traditional families concentrate their purchases on fresh food and basic ingredients, whereas Mainstream ones prefer delicious products. Golden consumers are those who buy products for intolerant people, sushi, sashimi, organic and sustainable products.

The two categories that grew the most in the last three years are those at the extreme sides: The Low prices and the Golden shoppers. The former increased by 2,5% whereas the latter by 5,4%.

It is therefore clear that the current trends in purchasing behavior will increasingly tend to polarize on these two segments. The first group has a focus on price, promotions and a preference towards discount channels. The Golden shoppers have an orientation towards value elements. They look for services, not just goods and they want quality products which are guaranteed by organic or geographical certifications. They pay attention to both tangible and intangible aspects, such ethics.

Exports

In the last five years Italian agri-food exports have increased by 23%, more than those of the 28 EU (+16%), exceeding 41 billion euro at the end of 2017. European agri-food exports reached almost 525 billion euros and 8% of this amount is Italian. During the same period, European food imports grew more than Italian ones (+ 16% vs + 10%).

Even if the Italian agri-food trade balance has remained structurally negative because of the dependence on foreign agricultural and semi-finished raw materials, it has significantly improved recently, going from -7.3 billion euros in 2013 to -4 billion in 2017.

Italian agri-food trade balance

SECTOR	2013	2014	2015	2016	2017	17/13	17/16
EXPORTS	MILLION €					VARIATION %	
Total	390.233	398.870	412.291	417.269	448.107	14.8	7.4
Agribusiness	33.494	34.331	36.894	38.429	41.025	22.5	6.8
-Agriculture	5.982	5.936	6.620	6.852	7.084	18.4	3.4
-Food Industry	27.512	28.395	30.274	31.577	33.942	23.4	7.5
IMPORT	MILLION €					VARIATION %	
Total	361.002	356.939	370.484	367.626	400.659	11	9
Agribusiness	361.002	41.917	42.900	43.071	44.998	10.3	4.5
-Agriculture	12.681	12.959	13.757	13.836	14.460	14	4.5
-Food Industry	28.111	28.958	29.143	29.235	30.538	8.6	4.5
	2013	2014	2015	2016	2017	13/17	16/17
BALANCE	MILLION €					VARIATION	
Total	29.230	41.932	41.807	49.643	47.448	18.217	-2.195
Agribusiness	-7.298	-7.586	-6.005	-4.643	-3.973	3.325	670
-Agriculture	-6.699	-7.023	-7.137	-6.984	-7.376	-677	-392
-Food Industry	-598	-563	1.132	2.341	3.403	-	1.062
NORMALIZED BALANCE	%					VARIATION	
Total	3.9	5.5	5.3	6.3	5.6	1.7	-0.7
Agribusiness	-9.8	-9.9	-7.5	-5.7	-4.6	5.2	1.1
-Agriculture	-35.9	-37.2	-35	-33.8	-34.2	1	-0.5
-Food Industry	-1.1	-1	1.9	3.9	5.3	7	1.4

Source: ISMEA (2018), Rapporto sulla competitività dell'agroalimentare italiano

In 2017, exports of food products grew by 6.8% compared to the previous year. Imports increased as well by 4.5%, a phenomenon due to the recovery in the demand for food products. Imports are linked to raw materials (coffee, wheat and other cereals) which are transformed by the national food industry.

Food industry gained almost 34 billion euros thanks to exports in 2017. This figure corresponds to 9% of the value of European food exports and it is 7.5% higher than the previous year. In the last five years exported food products have increased by 23%. Italy plays a key role as exporter also in the food industry sector, in fact it is always among the first suppliers.

Our country is the leading exporter of pasta and tomato preserves (65/66% of the EU exports). As far as wines and olive oils, Italy is at the second place, accounting for 27%

and 23% of the European exports, respectively. Concerning wines, sales increased by 6,2% in 2017. Wines are exported to three main countries: United States, Germany and United Kingdom, which take 53,4% of the total sales, much more than France and Spain (38,5% and 35,2% respectively). Finally, Italy is the fourth largest exporter of cheese and dairy products.

Italian agri-food exports are geographically concentrated. There are twenty countries that jointly absorb more than 80% of sales abroad. Italy exports mainly to Germany, France and the United States. However, in the last decade this concentration has decreased. Italian companies have therefore begun a process of greater diversification of its customers. Consequently, Europe has lost importance as exporter market and third countries have become more important. In the last years, Italian agri-food products addressed to non-EU markets grew by 7.3%, against 4.9% of those targeting the domestic market.

Italian agri-food exports to the top 20 destination countries

	Million €		Shares	
	2005	**2016**	**2005**	**2016**
World	21.000	38.446	100%	100%
Germany	4.491	6.742	21,4%	17,5%
France	2.551	4.203	12,1%	10,9%
USA	2.124	3.836	10,1%	10,0%
UK	1.939	3.244	9,2%	8,4%
Switzerland	920	1.476	4,4%	3,8%
Spain	1.060	1.451	5%	3,8%
Netherlands	693	1.398	3,4%	3,6%
Austria	708	1.241	3,3%	3,2%
Belgium	658	1.179	3,1%	3,1%
Japan	463	934	2,2%	2,4%
Canada	357	765	1,7%	2,0%
Poland	245	747	1,2%	1,9%
Sweden	292	646	1,4%	1,7%
Greece	555	626	2,6%	1,6%
Denmark	312	557	1,5%	1,5%
Australia	201	495	1%	1,3%
Czech Republic	191	434	0,9%	1,1%
Romania	81	422	0,4%	1,1%
Russia	291	409	1,4%	1,1%
China	22	357	0,1%	0,9%

Source: ISMEA (2018), Rapporto sulla competitività dell'agroalimentare italiano

Productivity

Labor productivity is one of the main factors driving the competitiveness of a country. Italy is characterized by a labor productivity which is not growing and consequently, our GDP is not growing so much as well.
In the last decade the agricultural sector was characterized by a positive productivity dynamic by considering the real added value per person employed. Specifically, between 2007 and 2016 it grew by 9.5%, while that related to the entire economy was 4.4% down. At current values, the value added per employee is higher than the EU average. This confirms the greater orientation of Italian agriculture towards high added value productions compared to the average of the EU partners. In 2017 there was a decline mainly due to the significant decrease in the agricultural added value even if employees employed decreased to a lesser extent.
For what food industry is concerned, the trend was moderately positive (+2.9%) between 2007 and 2016. Improvements were achieved between 2013 and 2017, when labor productivity grew by 4.9%. This should be considered a good result because it was achieved by increasing the number of employees.
Another index used by the European Commission to evaluate the productivity is the total factor productivity, which is a proxy for technical progress and efficiency in the use of productive factors in the agriculture field (i.e. intermediate inputs, capital, land and labor). According to the European Commission estimates, the index has remained stable for Italy over the last decades. However, between 2012 and 2016, improvements were made, even if the European progress was greater.
These figures show an agricultural sector that has maintained its position among the European leaders. However, it faces difficulties to improve its competitiveness compared to its partners and, therefore, it may lose ground in the future.

PDO, PGI and TGS certifications

According to Istat, Italy confirms itself as a leading country in terms of PDO, PGI and TGS awards recognized by the European Union. In fact, at the end of 2017, Europe recognized 295 Italian quality agri-food products.
PDO products (Protected Designation of Origin) represent the highest level of quality certified and protected by the European Union. They are certified because they come from a

specific geographical area: they have characteristics essentially or exclusively due to a particular geographical environment (including natural and human factors) and they are produced and transformed in a limited area. Up to December 2017, the Italian PDO products recognized by the European Union were 167 (one more than the previous year).

The PGI products (Protected Geographical Indication) identify the best agri-food specialties recognized and protected by the EU. They come from a specific geographical area and they are characterized by quality, reputation or other characteristics linked to a specific territory (i.e. they are produced or transformed into a limited geographical area). Up to December 2017, there were 126 Italian PGI products which were recognized by the EU, (three additional products compared to the previous year).

In 2017, fruit, vegetables and cereals (Altamura's lentils), extra virgin olive oil (Marche region), fresh meat (Piedmont region's beef) and dairy (Ossolano) sectors obtained a new certification.

TGS products (traditional specialty guaranteed) include recipes recognized and protected by the EU, whose peculiarities don't depend on geographical origin area but on a traditional composition of the product, a typical recipe or a traditional production method. A TGS product can be produced both in Italy and abroad and it can be certified by more than one control body while a PDO or PGI product is certified by a single body.

In 2017 Mozzarella and the Neapolitan Pizza were confirmed as the only traditional Italian specialties recognized by the EU.

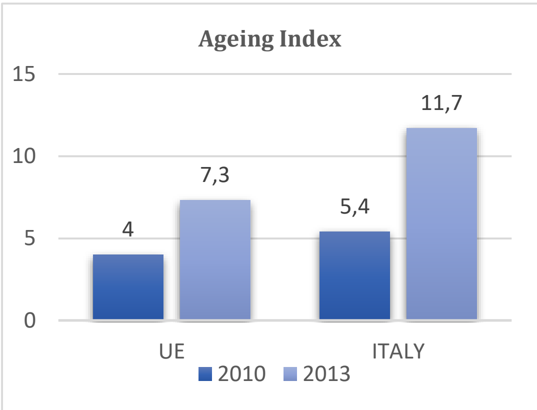
Company structures and human capital

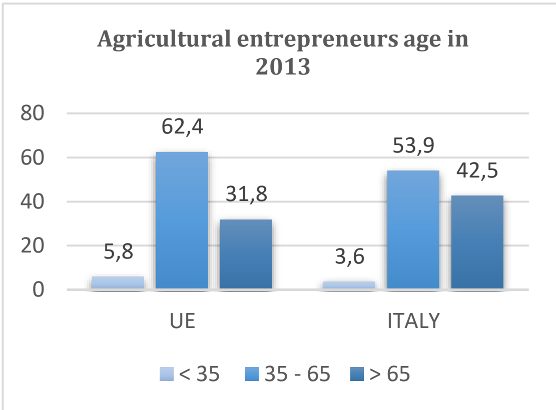
Information about farms has been collected by Istat's surveys. They show some evolutionary elements between 2010 and 2013, such as a slight increase in the lands owned by companies (8.4 hectares in 2013), a significant decrease in the number of companies that allocate most of their own production to self-consumption (from 40% to 22%) and a slight increase of agricultural entrepreneurs with agricultural skills.

However, there are two main problems related to these companies. First of all, the average standard product per company, which represents the "theoretical" gross value of company production, has remained around € 30.5 thousand both in 2010 and in 2013 (this is higher than the European one, but EU countries moved from 25.2 to 29.4 in that period).

Secondly, the entrepreneurs who are more than 65 years old increased from 32% to 42%, as well as the ageing index. In other words, the ratio between entrepreneurs over 65 and under 35 moved from 7.3 to 11.7. It means that in 2013, for each agricultural entrepreneur who was younger than 35 years old, there were 12 entrepreneurs who were older than 65. As a consequence, the inclination towards innovation is lower.

Ageing Index & Agricultural entrepreneurs age in 2013 tables





Source: ISMEA (2018), Rapporto sulla competitività dell'agroalimentare italiano

Despite the lack of dynamism, there are some peculiar elements of Italian agriculture sector. First of all, company diversification.

The 2010 Census provides details about farms that carry out activities other than agriculture, but connected to it. These are: holiday farms, recreational and social activities, educational farms, craftsmanship, first processing of agricultural products, transformation of farm products, production of renewable energy, woodworking, aquaculture, sub-contracting, breeding services, arrangement of parks and gardens, forestry, animal feed production.

Based on Census data, in 2010 there were 76 thousand companies involved (5% of the total) and the most common types of connected activities were sub-contracting and holiday farms. According to the same source, around 124,000 companies (8% of the universe) were involved in direct sales. A survey made in 2013 showed a higher percentage of farms involved in related activities (i.e. from 5% to 8%).

Industry 4.0 in the food industry

The industry is driven by the demand for shorter product life cycles, cost reduction and highly customized products. Food sector faces additional global challenges (Sartal, 2018):

- regulatory requirements and improvement of traceability
- sustainability
- time to market reductions

In the food sector the ability to innovate is considered one of the main element driving competitiveness. This is particularly true in Italy, where products coming from emerging countries are both competitive and well penetrated within the market. Innovation is significant because it allows a cost reduction and a better response to customer 's needs who require food products enhanced with services and with technological processing characteristics like quality, safety, ease of use and storability. Food firms are considered low tech. They are mainly process – innovation oriented and they use mainly new technologies developed by upstream industries. So innovation occurs throughout equipment and capital good investments (Capitanio, 2009). In addition, most of the innovations are incremental rather than radical.

Food industry invests 8% of the turnover in research and development (1.8% in formal and informal R&D to develop innovative products and processes, over 4% in new plants, automation, ICT and logistics and around 2 % in quality and safety analysis), combining know-how, traditions and made in Italy together with a constant process and product innovation.

Food sector is manly composed by small and medium enterprises (firms with less than 250 employees) which have limitations to access finance a well as internal competences for investments in in-house R&D activities. For this reason, it's fundamental for food SMEs to be able to acquire and manage external knowledge. A way to develop innovations in such scenario is developing relationships with university or research institutes. (Bigliardi et al., 2015). In Italy, these relationships take different forms: higher education apprenticeship, industrial Ph.D., contract research, contributions to scientific research, collaborative research, strategic consortia and so on (Iacobucci, 2014). Technology transfer offices (TTOs) are offices established by universities to disseminate scientific outcomes.

TTOs in Italy were established by the national law D.L. 27/7/1999 n. 297, and then regulated by D.M. 8/8/2000. The main activities carried out by Italian TTOs, range from creation of spin-offs and patenting to cooperation activities with firms and resolution of controversies and copyright properties (Bigliardi et al., 2015).

The Italian government has tried to improve the University – Industry linkages through tax incentives to encourage an increase in R&D spending, as well as many measures at regional level for the allocation of European funds. Furthermore, specific policies have been developed at national level, such as the National Plan for Research (2004 –2020) and the creation of several national technology clusters linking universities, research centres and firms.

In this context, Industry 4.0 could help companies to find solutions to these challenges. Industry 4.0 will turn manufacturers into predictors instead of reactors.

Tracking customers' preferences is simple with online shopping. Most websites keep this information to make it easier for customers to repeat orders. Predicting customer desires can increase profits by catering to exactly what people will buy, when they will buy it and how much they will buy.

Another way Industry 4.0 turns manufacturers into predictors is through equipment maintenance. Wireless sensors throughout a factory will collect data about performance and downtime of equipment. These sensors can determine when a piece of equipment requires replacement before it breaks down. For instance, vibrating screens require constant monitoring of their strength and tension and sensors can do this automatically.

The new information communication technologies (ICTs) allow the electronic commerce business-to-consumers. This can be considered a special kind of short chain strategy which reduces the organizational distance between producers and consumers, expanding the potential market from local to global. The ICTs helped the olive oil market for example. In fact, the olive oil supply chain is not well organized and coordinated as the market is characterized by power asymmetry. The possibility to sell directly to consumers allows to overcome the limitations of the long supply chain.

Food safety has risen several concerns recently. Customer confidence in the food industry has been destroyed by several food safety risk accidents and scandals such as cow diseases or genetic modified food. Consequently, several technologies have been applied to supply chain traceability and visibility. HACCP is a system of hygienic self-control in public establishments and in food industries. It provides that people in charge of food business must ensure that preparation, processing, manufacturing, packaging, storage, transport, distribution, handling, sale or supply, are carried out in a hygienic way. The UNI 10854: 1999 standard is the reference normative document at national level for the creation of a management system for self-control based on the HACCP (Hazard Analysis and Critical Control Point) method. Today, HACCP is the most widespread methodology to assess risks and dangers related to the hygienic safety of products and processes and to establish appropriate control measures.

Many authors have underlined several limitations in the HACCP application. These limits are related to the lack of worker motivation, awareness, interest and familiarity with food safety controls as well as poor planning of implementation, excessive documentation, lack of knowledge, competences, external support and resources. Another limitation is related to financial constraints (Herat, Henson, 2010). Moreover, we have to ask if the information shared in traceability systems can be trusted.

The technology which could help to solve these issues may be the blockchain. We usually consider blockchain linked with Bitcoin or more generally with virtual currency or financial transactions. In reality, the blockchain can be put at the service of the supply chain to have new tools able to guarantee the best food traceability in order to ensure new levels of food safety.

The British journal "The Guardian" wrote about the implementation of blockchain technology in the food chain, specifically in the fishing industry which is marked by both illegal fishing and no respect for human rights. Fish supply chains are not able to guarantee manufacturers, retailers and consumers the quality and reliability of all the steps. In other words, the real theme is to establish a trust situation. The blockchain is a digital ledger or record of information that is accessible to everyone. In this case it details the origins of fish and allows anyone to see where the fish was caught, processed and sold on. In the past, buying and selling of seafood was tracked by paper records and tags on the fish. This new approach allows local fishermen to send SMS messages to register their catch on the blockchain. This identification is then transferred to a supplier along with the catch, with any subsequent move, for example processing or tinning, also recorded. The information on the origin and supply chain journey of the fish can then be accessed and verified by end

buyers and consumers in shops or restaurants using their smartphones, replacing the current printed communication and labels (Levitt, 2016).
According to the theoretical framework, we can describe the blockchain as a distributed database: a chronological chain of blocks and each block stores all information of network activity since the block is added to the chain. All data is public, and any user can add data to it and check and copy this data at any time, but no one can change it. Therefore, blockchain is an immutable history of network, which can be shared among all nodes in the system. So this system removes the need for any centralized trust authority (Tian, 2017).
In case of damaged or contaminated products, this technology would allow food suppliers and other members of the food ecosystem to use the network of blocks to track down the contaminated products at the source. In this way it’s possible to quickly remove them from the shelves of shops, limiting the spread of intoxication or diseases.
In short, the blockchain technology applied in the food industry could transform the way organizations work and collaborate, raising the level of trust.
Anyway, deciding to move into Industry 4.0 requires a significant investment in new equipment and employees. Many manufacturers feel unready to replace equipment that still works well or replace less-skilled workers with technical professionals.
Training is a driver for the sector's competitiveness. Graduates are required knowledge linked to specific disciplines, such as: economy, marketing and management (35%); science, technology linked to food, biochemistry (25%); engineering, environmental science, logistics, supply chain management (21%), law (19%). Furthermore, more interdisciplinary skills will be required to support innovation. These are related to innovative technologies (nanotech, biotech, micro and nutraceuticals, soft processing, renewable energy); innovative models (consumer needs, new organization and distribution systems); innovative designs (packaging, ingredients and recipes, taste and colors, shelf-life, convenience and ready-to-eat, new qualities).
43,540 employees are expected to enter food businesses by 2021. If we exclude the approximately 15,000 graduates, the remaining 28,000 will benefit from apprenticeships and continuing education programs to acquire those essential skills to fit quickly and effectively into an increasingly automated and integrated production cycle.

Training hours aimed at supporting the digitization of business processes are 6,673 out of a total of 37,621, equal to 17.74%. The figure is not very significant numerically, however three factors must be taken into account:

- in the food industry digital innovation enters more slowly than other sectors due to the still handcrafted characteristics of the production processes;
- the beneficiary companies are small and micro enterprises which are not able yet to appreciate the advantages of the new technologies;
- the incentives provided by "Calenda plan" had not been launched yet when the training plans were presented and therefore companies didn't have the need to take part in training programs.

As training is a fundamental driver for the competitiveness of the sector and the enhancement of work, in 2010 an agreement was signed between Federalimentare, Associations and Labor Unions for the constitution of a permanent technical committee that has equipped itself with specific guidelines for the development and improvement of the training model. Up to May 2017, thirty-six national training programs have been financed and completed, 2,367 companies have been involved and over 19,928 workers have been participating.
Another issue concerns the fact that IoT provides a large amount of information and this creates digital waste and unnecessary information.

Industry 4.0 in the wine industry

Italy is one of the main wine producers in the world, in fact Italy produces about 18% of the global wine production (Muscio et al., 2016). In 2012 40 million hectolitres were produced. The regions which produce most of the wine are those where there are many varieties of high quality wines (DOC, DOCG and IGT): Veneto, where Prosecco, Amarone, Bardolino and Breganze are produced (over 700 million euros); Puglia, where Primitivo di Manduria, Squinzano and Negroamaro are produced (500 million euros); Tuscany where Chianti, Brunello di Montalcino and Vino Nobile di Montepulciano are produced (380 million euros) and Piedmont where Barolo, Moscato d'Asti, Nebbiolo, Franciacorta and Barbera d'Asti are produced (360 million euros).

Most Italian wine companies are family owned businesses, with families controlling 54% of the total net equity. Cooperatives account for a significant part of the total number of companies, although their proportion has decreased gradually over the years (Muscio et al., 2016).
Despite the fact that wine firms are considered low tech ones, they usually develop product, productive, commercial and packaging innovations to respond to or modify customer requirements.
The Fourth Industrial Revolution is increasingly involving the world of wine production. This is an opportunity to make more efficient work processes thanks to networked machines. For example, the alcoholic fermentation stage can be carefully controlled and monitored, but new technologies offer additional opportunities to winemakers. Nowadays it is possible to put sensors which collect data on soils and plants and micro-organism based diseases to save grape and wine harvests.
Many apps have already been created such as TracoVino. It was developed by MYOMEGA System Technologies thanks to a partnership with Ericsson, Telenor Connexion, Intel and wine producers (Maker Faire, 2017). This App is an internet of things solution that helps wine growers to enhance the quality of their wines, improve workflows and control vineyards remotely. It provides significant data like temperature, humidity, light intensity, air and soil humidity that are collected directly from the vineyards. The winemakers receive alerts, reports and predictive analysis based on this data on a tablet or a mobile.
According to Cortinovis, Berlucchi's agronomist, companies need investments, patience, commitment and training to implement precision viticulture. A barrier to the dissemination of this technology is the segmentation of the Italian territory. It is heterogeneous and for this reason there is the need to have a standardized data. A way to encourage winemakers and more generally farmers to invest in precision viticulture could be the availability of the territory's maps of force: they could be insert in the GIS platforms, for example. Anyway, a big mistake is to think that precision viticulture can replace the human eye. Actually it is only an additional useful tool which should be interpreted because it does not give answers. Consequently, expert personnel are needed.
Wine blockchain EY is another application that protects wine "Made in Italy" origin. It is the first system to guarantee a direct link between producer and end consumer through-

out a QR code on the wine bottle label. By scanning the code with a smartphone the consumer knows the producer as well as the process of cultivating, producing and finishing the wine. This direct interaction prevents counterfeiting while also allowing consumers to take a more direct role in quality control. The blockchain system creates a public database linked to the digital signature of the producer which cannot be modified or altered (Maker Faire, 2017).

Improving the customer experience is another key issue for wine makers. There are applications which focus on raising awareness and informing users about production and quality. VineAway creates virtual visits to vineyards, making it possible to follow each stage of the winemaking process. Winedering allows users to consult the archives and give their feedback or upload photos. SommelYou, Wikivinum and Wenda give users information about the bottle of wine by scanning the label, allowing them to learn the typical features of the vintage, ideal combinations or pairings, as well as the presence of any defects or corkage in the bottle.

Sipp is a company which offers a greater user experience thanks to virtual reality. Few years ago, the company launched a subscription wine club, offering carefully selected wines to its members. It developed an app through which it is possible to scan the label to find out information about the vineyard, temperature at which the wine should be drunk as well as suggestions about food to be eaten with. Its mission is to offer customer the possibility to enjoy great quality wines at their homes by getting a sommelier experience. Moez Seraly, who is the company's founder and CEO, thinks that augmented reality is a way to attract the millennials who drink a lot of wine at bars and restaurants but very little at their homes.

Even if drones have been around for few years, algorithms and programming updates will help winemakers to catch up to drone capabilities in the next years. Drones capture visual information which is translated into a data point throughout programming and computer power. The digital vineyard of the future might receive scientific real-time data collected by drones and transferred via a cell network. This technology offers several opportunities as pointed out by the Canadian case. In Canada, unmanned planes are monitoring vegetative heath. Global UAV Technologies Ltd., Jöst Vineyards, VineView and a Canadian telecommunications company completed a 4G proof-of-concept mission in in Malagash, (Nova Scotia), to demonstrate a real-word application of drone technology for a project called the "Digital Vineyard of the Future" (Miller, 2018).

As far as the online sale, a study has demonstrated that wine companies usually invest few resources in the electronic commerce. Udine University made a research on a sample of 48 wine firms with website headquartered in Friuli Venezia Giulia. They discovered that only few of them consider the website as a fundamental part of the marketing strategy as the majority think to it as a promotional tool.

Based on the research, companies tend to adopt e-commerce because of the demand from customers. The wine products sold by the majority of the companies are positioned in the medium-high quality segment, which makes them suitable for online sale. There are limitations in the e-commerce adoption because winemakers are reluctant to change and to adopt new technologies for selling their products as well as the lack of information and communication technologies (ITCs) and the skills to use ITCs. Furthermore, there is a lack of incentives and motivation to activate a real e-commerce site. (Mason, Moretti, 2015). In order to benefit from the advantages provided by online sale, Mason and Moretti (2015) suggest to develop a centralized e-commerce platform, where all the wines produced in Friuli Venezia Giulia are available for national and foreign markets. This system, which is called co-operative consortium, provides several advantages. First of all, firms can save money and share risks among the different participants. Secondly, companies can pool their resources to provide mutual support which in turn will strengthen their business sector without losing their business independence. For this reasons, developing a co-operative consortium could be a solution for all the wine companies that have not invested in an e-commerce channel yet.

Wine companies should combine the principles of innovation with those of tradition because the sector is characterized by changing consumption trends and established wine traditions of family businesses and it is also based on a strong regional identity (Vrontis et al.,2016).

Technologies are used to improve the quality of the products rather than the quantity. Tradition refers to the fact that wines are usually vinified by companies according to the most traditional company techniques. Tradition doesn't mean to make wine in the old way, but allowing the introduction of the necessary technologies to produce fine high-quality wine. The introduction of updated and different technologies represents a means to reach the desired products, a way to interpret wines also thanks to innovative tools (Vrontis et al.,2016).

Industry 4.0 in Agriculture

In 2015, the UN 2030 sustainable development agenda and the international community committed itself to ending hunger. Anyway we are far from the objective as about 800 million people worldwide suffer from hunger (De Clercq et al., 2018). According to the UN Food and Agriculture Organization (FAO), we will need to produce 70% additional food by 2050 even if the agriculture's share of global GDP is about 3%. There are four main issues which are putting pressure on agriculture:

- ❖ demographics;
- ❖ scarcity of natural resources;
- ❖ climate change;
- ❖ food waste.

Demographics reflects the fact that population is growing: world population is expected to reach 11.2 billion by 2100 (De Clercq et al., 2018). As population grows, more food will be required. In addition, the global diet is changing too. Because of the urbanization as well as the rising in incomes, people require more high-value animal proteins.

As far as the scarcity of resources, it's significant to point out that the farmland is increasingly becoming unsuitable for production: 25% of global farmland has already been considered highly degraded whereas the 44% of it is little or moderate degraded. Land shortage has resulted in smaller farms, lower production per person and greater landlessness. In several areas there is also water scarcity because of the climate.

Climate change is linked with a reduction of productivity because of the variability of precipitation, the frequency of droughts and floods which result in a reduction of crop yields. Even if higher temperatures can increase crop growth, crop yields decrease when temperatures exceed a certain level.

New technologies can help to overcome these issues. The new technology revolution should take into consideration both the demand and the supply side. Technology shouldn't be used only to create innovations, but also to address the issues we have pointed out before, addressing customer's needs and reengineering the value chain.

Specifically, agriculture 4.0 allows to:

- produce differently using new techniques;
- use new technologies to bring food production to consumers, increasing efficiency in the food chain;
- incorporate cross-industry technologies and applications.

Farms are beginning to experience the benefits of agriculture 4.0 in terms of cost reduction, quality and crop yield, but things can improve, not only in the field, but along all the processes of transformation and distribution. An analysis conducted on 57 case studies shows that technologies allow agri-food companies to improve and innovate quality, particularly as regards the valorisation of the origin of the products, the guarantee of production processes and food safety.

A strong innovative drive comes from new companies, with 481 Smart agri-food international start-ups born from 2011. Most of them are American (52%) whereas the Italian ones are 12% of them. Among the most relevant sectors there is the fruit and vegetables one. In Italy, the most important sectors in terms of technology implementation are fruit and vegetables, wine and cereal.

Already implemented solutions are big data and analytics, software platforms, latest generation devices, mobility and geolocation and internet of things. Other solutions are represented by vehicles and related equipment and ICT on cloud systems. In general, 80% of these solutions can be applied to the cultivation phase, whereas 12% of them to the planning.

The digitalization of agriculture is based on the development and the introduction of new tools and machines in production. Connectivity and localisation technologies (GPS) are optimizing the usage of tools like tractors. Driver assistance allows to optimise routes, to shorten harvesting and crop treatment and to reduce fuel consumption. The deployment of sensors on tools allows to monitor and control crop treatments, gaining efficiency and productivity. Another important transformation in the agricultural production process is the relevant role of automation that increases productivity by reducing the need for human workforce. This can take several forms, from the automation of vehicles, to the development of task specific robots that automate some phases of the production process.

Finally, a key transformation is linked with the ability to collect more data about production: soil quality, irrigation levels, weather, presence of insects and pests. This is possible thanks to sensors deployed on tractors and tools as well as the use of UAVs or satellite imagery to collect measurements from above.
By 2020, over 75 million agricultural IoT devices will be in use and the average farm will generate 4.1 million data points daily in 2050 (De Clercq et al., 2018). These advances will make businesses more profitable, efficient, safer and environmentally friendly.
IoT technologies are particularly significant in this industry because they allow machines to become more precise and smart. Think about drones. They produce precise 3D maps for soil analysis or they get data for managing irrigation and nitrogen levels or they scan the ground easier and faster than traditional machines. There are also start-ups which have introduced drone planting-systems capable to provide all the necessary nutrients to the soil for growing crops. Drone-carried devices help to track changes in plants and this is useful to identify diseases.
A new technique of production is the hydroponics which is a way to grow plants without soil, using mineral nutrient solutions in a water solvent. Sundrop is an Australian company which developed a hydroponics seawater to grow vegetables in any area of the world. The benefits of these technologies are linked to the fact that no land is required and no pollution is produced.
Another example is given by The King Abdullah University for Science and Technology (KAUST) in Saudi Arabia. It is developing techniques to allow the growth of plants in deserts by studying genome engineering, growth regulators, plant hormones and microbes whose association with plants let them to survive at extreme conditions.
Vertical farming is the process of growing food in vertically stacked layers, producing food in challenging environments where suitable land is unavailable. It uses soil, hydroponic, or aeroponic growing methods (the process of growing plants in an air or mist environment without the use of soil, similar to hydroponic). The process uses 95% less water, less fertilizer and nutritional supplements and no pesticides, while boosting productivity (De Clercq et al., 2018). For instance, Plenty's field-scale indoor farms located in San Francisco, combine agriculture and crop science with machine learning, IoT, big data and climate-control technology. In this way, healthy food grows with little water and energy

need. Plenty has received significant investments from SoftBank Vision Fund and Amazon CEO Jeff Bezos which will help to further invest in technology.
Another example of vertical farming is provided by Farm66, which is a high-tech vegetable farm in Hong Kong 's Tai Po district which has been producing vegetables since 2013. This farm covers about 20.000 sq. ft. space and it can produce 150 tonnes of vegetables per year, such as lettuce, wild rocket, endive and cabbage for salads which are supplied to more than 100 supermarkets. The most fascinating thing about Farm66 is that vegetables are produced within a building, not at open air. Workers use computers and drones to cultivate plants supported by air conditioned, led lamps and sensors that control temperature, humidity and height of vegetables to make sure that the environment is kept stable for the growth of greens. Led lamp are very important because different colours can influence the growth of vegetables. For example, blue light can stimulate leaves to grow larger and wider, red light can help stems to grow thinner and longer and white light is like normal sunshine. In other words, they can improve the growth of different vegetables by changing the proportion of red and blue lights.
Anyway to be a cost sustainable initiative, vertical farming should rely on affordable electricity and the governments should support it through tax incentives and power subsidies.
Blockchain technologies can be implemented in the agriculture field in general, other than the specific wine and food industry. They can prevent price extortion and delayed payments while simultaneously eliminating middlemen and lowering transaction fees, leading to fairer pricing and helping small farmers to capture a larger part of their crop value (De Clercq et al., 2018).
Nanotechnology is helping to provide plants with a precise dosage of nutrients, fertilizers, agrochemicals and pesticides. This results in less pollution and healthier soils as the biodiversity is preserved. In other words, nanotechnology preserves the fertility of the cultivated soil rather than dry it up with intensive monocultures.
Technology has enabled people to share goods and services, think about houses or cars. But sharing economy can be applied to every industry, agriculture included. For example, Olio is an app connecting people with their neighbours, local shops and cafés so that surplus food and other items can be shared, rather than be thrown away. It has been developed in 2015 by Tessa Clarke and Saasha Celestial One, two English social entrepreneurs. They started from a market research and they understood that a third of food produced

globally is discarded. Before investing money in such initiative, they created a WhatsApp group where they asked participants to share food surplus for two weeks. The trial had positive results, so they built the minimal viable product version of the app, supported by their first investor: Simpleweb which is a development agency. They launched the App in the App store in July of 2015, followed by Google Play three weeks later. Now they count for 714045 users and 22396 volunteers.

Olio is available to be used anywhere in the world and food has been successfully shared in over 32 countries so far. The app navigation is in English, however listings and messaging can all be done in local languages. They obtain money because companies have to pay to take part to the "Food Waste Heroes Program". Companies pay for the service and an Olioer collects food waste from them, so they have no edible food waste stores. An Olio Food Waste Hero is an Olioer who picks up unsold surplus food from businesses to save it from discarding. Each FWH is part of a team of volunteers who is in charge of collecting the unsold food, bringing it at home, listing it on the Olio app, and redistributing it to his neighbours, who pick up the food.

However, Olio is not the only app to provide this type of service. There are several companies all over the world, such as Food Cowboy which is based in Maryland or Meal Sharing located in Chicago.

Despite the benefits in terms of cost reduction, quality and yield of the crop, the spread of these solutions is still limited in Italy and less than 1% of the total cultivated area has been managed with these systems till now.

Many Italian SMEs are taking part in the digital transformation of agri-food, but a strong innovative drive comes from new businesses. Among the Italian companies that have invested in new technologies, 51% of them use digital technologies to enhance quality, particularly in the case of products characterized by a high added value, such as wine, cocoa and coffee. 46% of firms use digitalization to improve food security and 25% of businesses focus on production techniques, especially regarding aspects related to environmental impact, animal welfare and the agri-food traditions of the different territories. Finally, 12% of companies use technology to improve the quality of service, adopting innovative solutions to communicate product information (nutritional advice) and process information (origin, traceability and environmental impact) to consumers (Osservatiorio Smart AgriFood, 2017).

In Italy, Agriculture 4.0 has met several obstacles. First of all, there is a cultural barrier to innovation and a limited awareness of benefits, as well as underdevelopment on the part of the supply actors, who are just now structuring to offer solutions that are in line with the companies. Another obstacle is represented by the limited size of farms.

Firms should be able to fully appreciate the potential benefits of the revolution 4.0, touching the concrete benefits obtained by those who have already done investments. We have also to take into consideration the fact that technological standards are required to ensure the compatibility of different equipment. In fact, digital technologies can fully deploy their potential only if certain conditions are met. First of all, it is necessary to extend the broadband and extra-wide band to rural areas to guarantee the interconnection of the supply chain.

Furthermore, companies need sensitivity, expertise and willingness to invest. This point shouldn't be undermined, as the majority of Italian firms are of small and medium size. Finally, the expertise of both the supply and demand operators is essential. Agriculture 4.0 requires professional figures that did not exist until a few years ago. Universities and technical institutes should teach about mechatronics, sensors, algorithms and geographic information system in order to shape the future farmers. In addition, the arrival of young people, who are confident with new technologies, will help companies to grasp the fundamental opportunities offered by the technological revolution.

Smart agri-food

Smart agri-food finds a place in the 4.0 Industrial Plan presented by Renzi and by the Ministers Calenda and Padoan. There are incentives to support the purchase of new technologies in the agricultural and agri-food sector. The main objective is to reach 10 percent of precision agriculture within three years. According to Filippo Renga, who is co-director of the Smart Agri-Food Observatory, the problem is that small agricultural firms don't have access to these incentives because they don't make financial statements (being taxed on agricultural income). For this reason, it's important to find out more effective instruments. Among the most virtuous examples of companies that have decided to invest in Agriculture 4.0 there is Bonifiche Ferraresi Spa, which is the largest Italian agricultural company, listed on the stock exchange with a production value which was 14.3-million-euro worth in 2017.

"Using these technologies means finding a balance with the environment and transforming this value into an economic advantage"

Francesco Pugliese, R&D Department Director at B.F. Spa

Bonifiche Ferraresi S.p.a. performs a physical and chemical digital mapping of lands, which allows it to know how many agricultural products it is possible to cultivate in its land without drying up or wasting resources. Last year the company obtained a 15-20% reduction in fertilizer use compared to 2016 and a similar decrease in the passage of tractors and agricultural vehicles in the fields.

In order to promote the large-scale dissemination of agriculture 4.0, Bonifiche Ferraresi launched a partnership with the public-private company Ismea in 2017.

According to Mr Pugliese, it would be more effective if the incentives pushed to take virtuous and sustainable behaviours: they should be given to those companies which demonstrate to minimize environmental impact by using Agriculture 4.0 techniques.

At the same time, with the evolution of the agricultural world there is a major need for new professional figures. In Jolanda di Savoia (Ferrara), Bonifiche Ferraresi has developed a university campus within the company to connect students and businesses to share know-how.

In Tuscany the firm has created post-graduate agricultural schools dedicated to precision agriculture thanks to a partnership with local institutions. The company has also made itself available to host the University of Teramo Master course on precision agriculture.

Mr Pugliese affirmed that contributing to the sharing of knowledge and skills also allows the company to create new professional resources, which are still lacking in the market today.

CHAPTER III

This chapter aims at introducing a selected presentation of technologies used in the agri-food sector. In order to examine them, I used scientific papers written in the last ten years by authors from all over the world. To describe how machines work I took into consideration also technical documents such as US patents.
For what technologies are concerned, I was interested in their operation, as well as their components. In terms of implication, I deeply analyzed their benefits and disadvantages.
These technologies are all implemented in agri-food Italian companies but they may be implemented in many other different industries such as military or manufacturing.
The order in which they are presented is the alphabetic one.

Agricultural Decision Support Systems

Agri DDS are IT resources which help farmers to make decisions concerning crop production. These systems incorporate data on climate, water, genetic, landscape, human and economic factors and they provide information about how this data work together influencing productivity as well as quality. As agriculture becomes more intensive, the demand for higher level of environmental control increases. Consequently, a model is needed.
"A model is a schematic representation of the conception of a system or an act of mimicry or a set of equations which represent the behaviour of a system, with the purpose of aiding, understanding and improving the performance of the system" (Mahdi et al., 2018, p. 167).
Crop models are software which mimic crop development and growth. The model simulates the behaviour of the crop by predicting the growth of its components. For this reason, it's possible to affirm that models don't predict only the final state of production, but they also provide information about the processes involved.
Over the years, several Decision Support Systems (DSS) were developed also in the wine industry to help winegrowers, vineyard consultants and other viticulture experts in the management of grapevine disease, as well as other important factors for vineyard management activities.

At the beginning, those systems were often too expensive for most of the growers and they weren't really user-friendly. But things have changed with the improvement and accessibility of IT technology and DSS are nowadays widely available for both smaller and larger winegrowers. A comprehensive DSS for vineyard management includes several components such as decision support for canopy management, disease, and pest control, scheduling irrigation, alerts on potential hazards such as freeze or hail storms, control of the growth phase of grapevines and grape ripening, precise and efficient usage of fertilizers, as well as estimates of yield and costs.

As far as winery, DDS should be able to forecast disease and pest to help winegrowers to determine the best timing of spraying application. With the technology improvement, many techniques for disease forecasting have been developed and re-adapted to suite to specific climate and location.

The essential feature of those models are agro-mathematical algorithms that provide information about the use of pesticide application and cultural practices to improve crop quality and productivity. They work on the basis of collected data from automated weather stations, site-specific weather products and weather forecasts, in combination with provided field data and knowledge base.

DDS are based on models that represent the problem, thus allowing managers to virtually change parameters and observe the implications in the final results. Models could be very different from each other. In the following paragraph the main models are presented.

- ❖ Empirical models: they are expressed through regression equations and they are employed to estimate the final yield. They take into consideration observed data. An empirical model is for example the one used to test the response of crop yield to fertilizer application.
- ❖ Mechanistic models: they copy relevant physical, chemical or biological processes to describe how and why specific responses occur.
- ❖ Static and dynamic models: a static model is the one that doesn't contain time as a variable. On the contrary, a dynamic one is a model which includes time as a variable. The latter is expressed as differential equations.
- ❖ Deterministic models: they provide predictions about quantities such as crop yield and rainfall. They don't take into consideration probability distribution, variance

or random events and for this reason they may lead to inaccuracy. Anyway, if uncertainties are not relevant, they may be adequate.

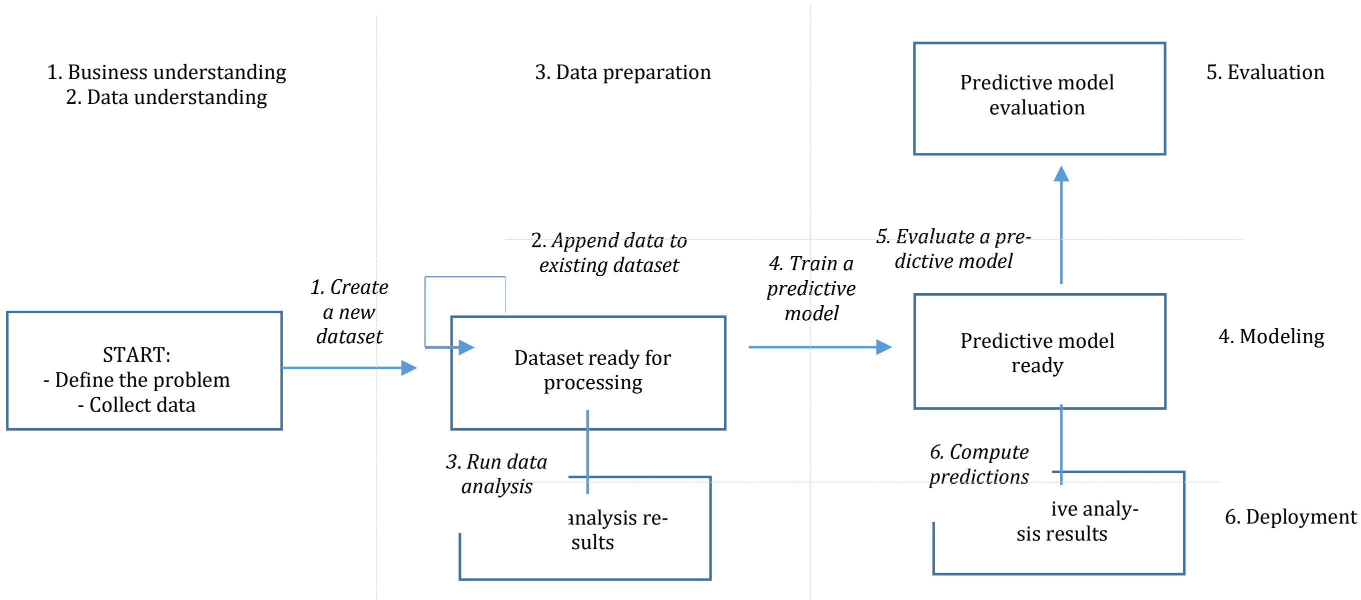
- Stochastic models: they are the most suitable models in case of high levels of uncertainty because they provide an expected mean value as well as the associated variance. Anyway this model is difficult to handle, so it's better to start with a deterministic one and change it only if results are not successful.
- Simulation model: they copy the behaviour of a system. They are designed to mimic the behaviour at short time intervals, so the variability related to daily change in weather and soil conditions is taken into consideration.
- Optimizing models: they provide the best option in terms of management inputs. They are based on decision rules which are consistent with some algorithms.
- Weather data for modeling: solar radiation, temperature and precipitations are used as inputs in Decision Support System for Agro technology Transfer (DSSAT). In these models, weather is used as an input. This model is particularly useful in the United States, Europe, India and Africa. In particular, Indian crop is highly influenced by the monsoon rains whereas the African one is influenced by shortage of rainfall. This model is useful because it allows to evaluate alternative management strategies.

The literature has identified four levels of production:

- Level 1: the growth of the crop depends on the weather conditions but there is no shortage of water or nutrients.
- Level 2: there is shortage of water
- Level 3: there is shortage of nitrogen
- Level 4: there are low level of phosphorus and other mineral nutrients

Diseases, insect pests and weeds can occur at each of these production levels and they can reduce the growth of the crop. Consequently, a useful model should consider all the variables.

The following scheme represents the workflow within an Agro DDS System.



Among the most implemented agro DDS we find: DSSAT, WOFOST, InfoCrop, AquaCrop and APSIM.

The Decision Support System for Agrotechnology Transfer is a software which includes crop simulation models for over 42 crops. It is supported by many different apps and programs for soil, weather and crop management and it needs daily data. This model simulates growth, development and yield as a function of the soil-plant-atmosphere dynamics. WOFOST (World Food Studies) is a simulation model for the quantitative analysis of the growth and production of annual field crops. It is a mechanistic model that explains crop growth on the basis of the underlying processes, such as photosynthesis, respiration, and how these processes are influenced by environmental conditions (Mahdi et al., 2018). It can predict data about production, water use and nutrient levels. This model was developed and it is continuously updated by Wageningen Environmental Research in co-operation with the Plant Production Systems Group of Wageningen University & Research and the Agri4Cast unit of the Joint Research Centre in Italy.

InfoCrop is a generic crop model which simulates the effects of the weather, soils, agronomic management (planting, nitrogen, residues, and irrigation) and pests. It provides information about crop growth, the effects of water, nitrogen, temperature on crop development and the interactions between crop and pests. This model is easy to implement and to understand and it requires easy available inputs.

AquaCrop is the crop growth model developed by FAO to address food security and assess the effect of the environment and management on crop production. It simulates the response of herbaceous crops to water and for this reason it's particularly useful in case of water shortage.

The Agricultural Production Systems Simulator (APSIM) is considered to be the most advanced simulator at the international level. In fact, it allows the simulation of systems that cover a range of plant, animal, soil, climate and management interactions. These models are scientific tools able to support decision making processes as well as innovations within the organizations, anyway in order to choose the most suitable DDS, it's necessary to adopt the one which integrates with the existing sensors or data collecting systems. Furthermore, Branco et al. (2015) stated that in order to be efficient and successful, DSS must be flexible, adaptive and extremely interactive and dynamic.

Among the most important players, we find international companies such as John Deere, TopCon Positioning Systems INC, Trimble and Smart Ferilizer Management.

John Deere was founded in 1837 in Illinois and it offers products and services for the land management. It has been providing solutions integrated with technology since 2014.

TopCon Positioning Systems INC is an American company that serves agribusinesses, professional farmers and agricultural contractors with leading edge, innovative technologies to improve farm efficiency.

Trimble was founded in 1978 in the Silicon Valley. It offers solutions which are used in 150 countries around the world.

Smart Ferilizer Management is a young American company as it was founded in 2014. Its vision consists on helping agriculturalists to make the right decisions so that they can increase their profits and improve the environment.

At the Italian level, we can mention Agricolus S.R.L. which is an innovative start up that developed a cloud ecosystem of precision farming applications.

Automated warehouse

An automated warehouse is a warehouse where goods are automatically stored in and removed from it. The type, quantity and location of goods stored in the warehouse is normally recorded in a data base which is used to manage the warehouse.

Within an automated warehouse there are pallets which contain goods. In the past, all the goods contained in a pallet should be of the same type, but nowadays it is not necessary anymore because technological improvements have been made at the data base level. Goods are loaded from the warehouse by removing the pallets. When goods are to be out loaded, a pallet is withdrawn from the rack by a stacker crane, and it is placed on a receiving platform. The pallet is then transported outside the warehouse on this platform, and goods are removed from the pallet to be delivered to the different locations outside the warehouse.

An automated warehouse includes a storehouse for housing goods. A pallet outloading means is employed to remove goods from the storehouse whereas a pallet inloading means is used to bring them inside it.

The main feature of this warehouse is that inloading and outloading are performed automatically. Goods which should go outside the warehouse are removed from the storehouse and they are withdrawn from the pallet thanks to picking means. Goods which should enter into the warehouse are insert thanks to filling means. Picking and filling means are connected through a pallet transport means.

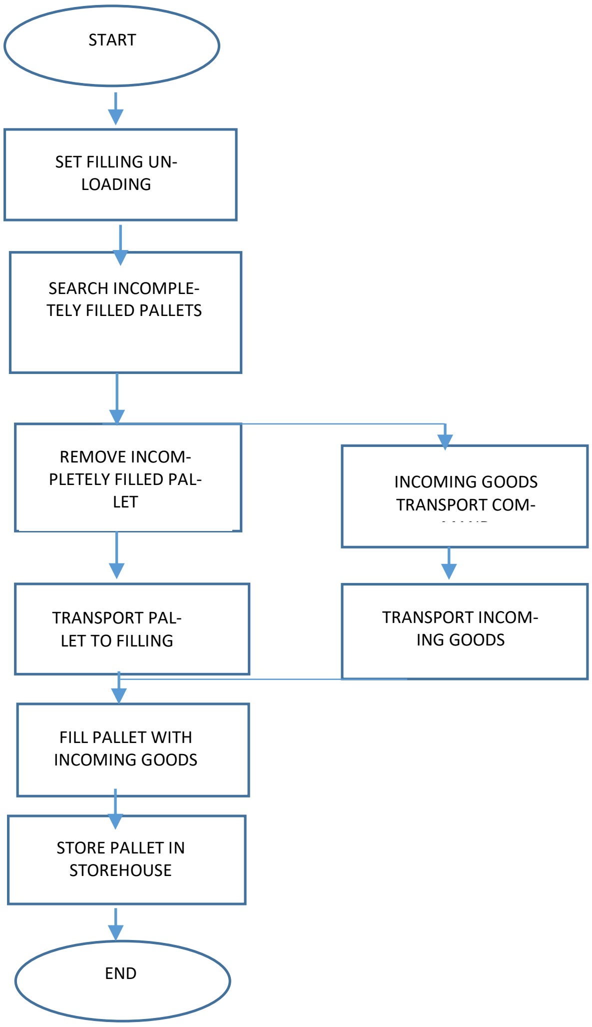
A buffer is installed in the filling means. When goods are brought into the warehouse, pallets stored in this buffer are looked for. If there is a pallet in the buffer having a suitable space to accommodate the incoming goods, this pallet is removed from the buffer and the goods are filled in this pallet which is then stored in the storehouse.

If no suitable pallets are available in the buffer, a fresh one is removed from the storehouse to fill in the goods. The existence of a buffer allows timely operations, because most of the time pallets are ready to be filled, without the need to recall them from the storehouse and wait for.

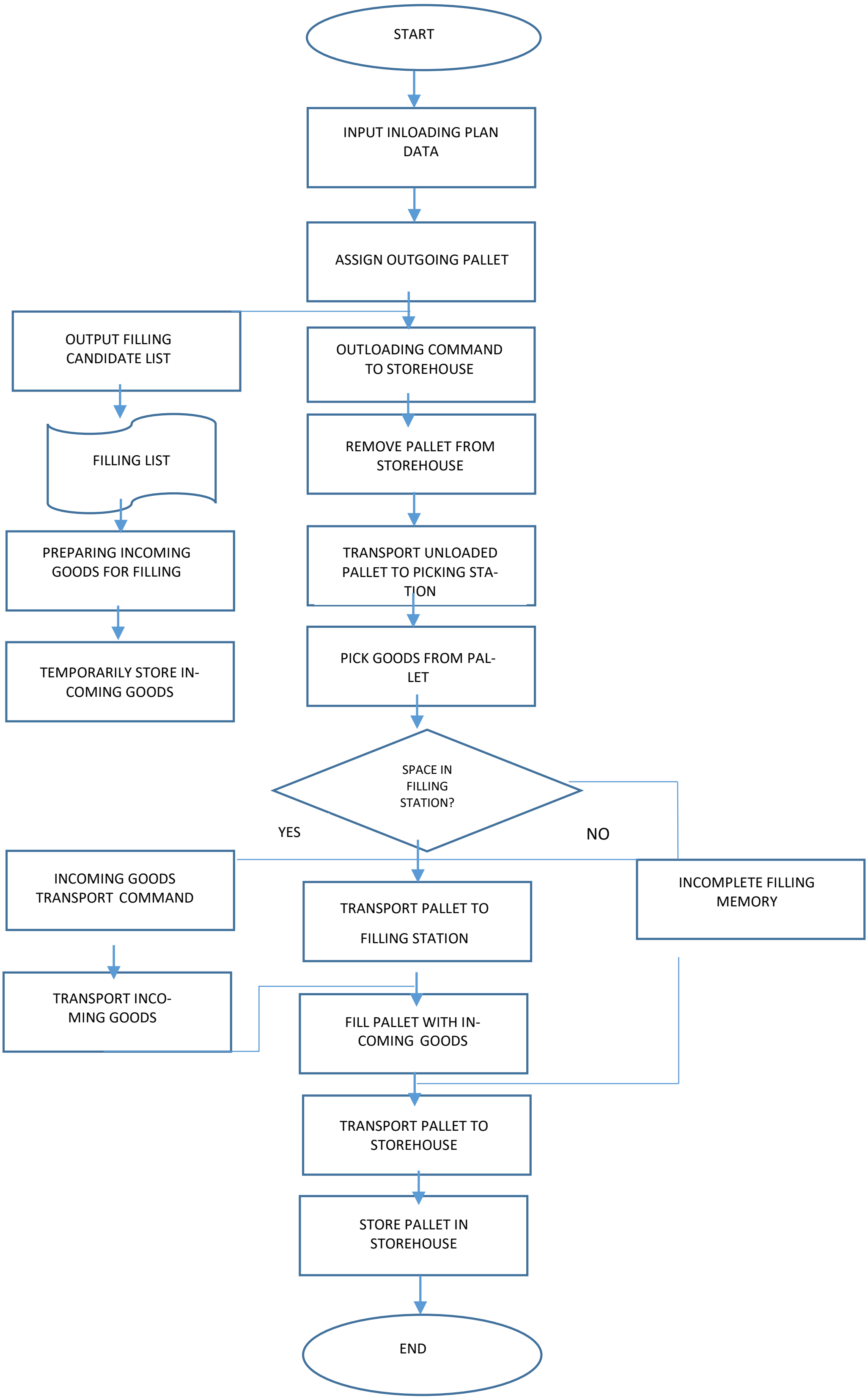
All the operations are managed thanks to a command control means which is equipped with a memory for memorizing the storage status. The command control means is composed of a computing means to compute the space which is created in a pallet by removing some goods from it, a space recording means to record the amount of space computed by the computing means and a selection means for selectively specifying goods to match the amount of space created in the pallet.

The computing means includes a first occupancy volume computing means for computing the volume occupied by goods removed from a pallet from. This means computes their width height and depth. The amount of storage space created in the pallet can be detected and registered when the goods to be delivered are removed, or on the base of a set delivery plan data.

In the following flowchart it is explained how new goods are filled within the warehouse.



The next flowchart explains the operations needed to deliver goods outside the warehouse. This figure shows the entire sequence of operations from removal of goods to detection and recording of storage space, and from filling of incoming goods to warehousing of pallets.



The main advantages provided by an automated warehouse are: storage efficiency and speeding up delivery or warehousing of goods. Speed increases because the system can simultaneously identify where items of a given order are. In addition, the system can also find out the best route to collect goods, maximizing productivity. Anyway there are also other benefits carried out by this invention. Firstly, it allows to decrease costs. In fact, it requires a huge investment at the purchase moment, but then it pays for itself in the long run as less workers are needed to perform the same amount of work in less time. Secondly, automation helps to maximize space as it uses more vertical storage space because robots and machines can retrieve goods from high, safer and faster than humans. Consequently, 40% of floor space is saved.

The disadvantages of an automated warehouse are mainly linked to the huge financial investment need to design, fabricate and install it within an organization and the higher level of maintenance required. In addition, a lower level of flexibility has been registered compared to a manual system. Finally, someone affirms that there are disadvantages in terms of employment. As I pointed out before, less workers are required, so some of them could lose their job. Anyway, this technology should be conceived as an instrument to relieve humans from repetitive, hazardous, and unpleasant labour. Workers may be destined to additional and more creative jobs, where machines can't substitute them.

The major players which produce automated warehouses are: Kardex group, Hanel, Ssi Schäfer, Ferretto Group and Modula.

Kardex is a Swiss group which operates in more than 30 countries worldwide and it is made of two divisions. The one specialized in producing automated warehouses is Kardex Remstar.

Hanel is a German firm that has been providing solutions for innovative intralogistics for more than sixty years and it has been the first company to introduce an Eco Drive system able to transform kinetic energy into electrical one.

Ssi Schäfer is a German company founded in 1937. It operates in many different sectors: from fashion to food and beverage.

Ferretto Group is an Italian company which was founded in 1956 in Vicenza. The firm provides a complete range of avant-garde solutions for all storage, handling and archiving activities, supporting customers in all phases: from design to installation, through servicing and maintenance during the entire life of the installations.

Since 1987 the Italian company Modula has been an example of manufacturing excellence and innovative firm. All the components of vertical automatic warehouses are made within the company, from raw materials to finished products.

Drones

The technical name of drones is Unmanned Aerial Vehicles (UAVs). They were first introduced during the WWI for enemy surveillance but nowadays they are employed in several applications such as industrial monitoring, photography, battlefield surveillance, air ambulance and packages delivery.
As far as the distance they can operate, there are two types of drones: the short distance flying objects, which are called single-operated pilot, and the long distance ones that fly at higher altitude.
As far as their features, they can be classified into two main categories: Fixed Wing Airplanes (a) and Rotary Motor Helicopters. The former can fly at higher speeds (between 25-45 mph) and it can cover from 500 to 750 acres per hour. The latter can fly at constant speed. It can take off and land off in small confined areas and its battery isn't powerful. This is the best type to learn how drones can be used.
Concerning rotors, we can find different models: single rotor helicopter (b), quad copter (c), hexa copter (d), octo copters (e).
A single rotor helicopter is a drone with one big sized rotor on the top and one small sized on the tail. The other ones are multi-rotors with four, six and eight rotors respectively. Particularly, the quad copter is equipped with four rotors which allow it to lift. The two opposite rotors are turn in clockwise direction and the other two turn in counter clockwise direction. The movement around the axis includes pitch (backward and forward), roll (left and right) and yaw (clockwise and counter clockwise) (Mogili, Deepak, 2018). There are two configurations of this model: plus and cross. The cross one is more popular and stable compared to the plus one.

a b c d e

Fig. 1. UAVS types. Mogili et al. *Review on Application of Drone Systems in Precision Agriculture*. Procedia Computer Science 133 (2018) 502–509

Another aspect to consider is the ground control station. It is the place in which the operator stands and monitors the flight and the data captured by the drone. There are simple systems which can be monitored through a smartphone.
Different software has been developed to analyze data. The majority stich together separate images into one smooth picture and then they incorporate the image into GIS systems. After that, variable-rate applicators can employ these pictures to find areas of the field which need additional nutrients of water. They are photogrammetry software. The most known are: PhotoScan^{R}, PIX4D, Apero-MicMac, VisualSfM and Bundler. They are employed to obtain geomatic products from UAVs, like georeferenced orthoimages and digital evolution models (DEM) (Ribeiro-Gomes et all., 2016).
Drones can be manually flown or the flight can be pre-determined thanks to GPS data. The flight controller is the main board in drones as it checks a lot of parameters during the flight time.
UAVs cost from 1000$ to 10.000 or 20.000$ depending on size and additional features. In case of crash, they are designed to have components which are easily replaceable.
In recent years they have been integrated with HD cameras like GoPro, DjI, Parrot, which allow to stream real time videos of flight on smartphones or tablets. The simplest drones are equipped with a basic digital camera which takes still pictures. A basic digital camera can be a Canon or a GoPro. Anyway, other types of sensors can be mounted to obtain more precise data. For example, some drones are equipped with cameras which take near-infrared images. Healthy plants reflect both green and infrared wavelengths of light. When plants are stressed, the type of light reflected changes. Healthy plants appear bright red, meanwhile stressed ones look darker (Stehr, 2015). Other components embedded to the UAV are IMU to measure angular rate and forces, thermal cameras to record low light imaginary, laser scanner 2D to capture shape of objects, air pressure sensor to measure gases or liquids.
Image noise and blurring can influence the quality of the pictures acquired. As far as noise, it is mainly electronic noise and it can be minimized by equipping drones with high quality cameras.
For what blurring is concerned, we can identify two types: global blurring and local blurring. The former occurs when all the image is affected, the latter happens when only some parts of the picture are affected. Global blurring depends on a camera which is shaking or

out of focus (this is the main type involved with drones), whereas local one can be classified into depth of field and moving objects types (Ribeiro-Gomes, 2016).
Anyway, there is a lower probability of blurred images using drones because they are acquired with focal length set to infinity and the illuminance is usually good, so an adequate exposure can be reached by balancing the ISO.
In addition, there is a shutter speed, a diaphragm aperture and the distance to the object is usually greater than the hyper focal distance of the utilised lens.
Climatic conditions such as wind may cause blurred images as well. Different techniques to detect blurring have been developed by different authors. Each one has its pros and cons, so the most suitable one depends on the purposes as well as the type of blurring and the causes. For example, Tong, Li, Zhang and Zhang (2004) have developed a technique based on the edge sharpness analysis. Anyway this is not useful for agricultural purposes because images which are obtained from crop haven't clear edges.
Another method is the low depth of field image segmentation. This is suitable when local blurring occurs so it is not suitable for images taken throughout UVAs because they're mainly affected by global blurring rather than local one.
The blind image deconvolution requires the determination of a blurring kernel to estimate a latent un-blurred image of the same scene. In order to do this, a multi-channels camera is needed because it allows to determine motion blurring by taking into consideration the phase differences between channels. Anyway this type of cameras is very expensive.
Another technique is based on the lowest directional high frequency energy. This is not accurate when blurring is influenced by climatic conditions such as wind.
The Federal Aviation Administration has developed several rules. For example, they can't be used by commercial companies, they should be within line of sight of the operator under 400 feet and they can't fly within 5 miles of airports.
According to the latest researchers, 85% of drones are employed for military reasons whereas the 15% for civilian applications. In the agricultural sector, they are deployed to perform different tasks:

- ❖ Analysis: they can be used to inspect the field conditions at the beginning of every crop year because they fly in the sky and they generate 3D maps which provide information about irrigation need and nitrogen levels.

- ❖ Time saving: they allow to monitor crops regularly
- ❖ Higher agricultural yield
- ❖ GIS mapping integration: this allows to draw field borders
- ❖ Imaging of crop yield status

UAVs are particularly useful for crop monitoring because they can observe it with different indices. Thermal and multi spectral cameras allow to record reflectance of vegetation canopy. The camera takes one pictures per second and then it sends them to the ground station through telemetry. A MAVLINK protocol is used for this wireless connection. Data coming from the multi spectral camera is then analyzed through a software which allows to compute the Geographic Indicator Normalized Difference Vegetation Index (NDVI), according to the following equation:

$$NVDI = (R\ inr - R\ red) / (R\ inr + R\ red),$$

where R inr stands for reflectance of the near infrared band and R red stands for reflectance of the red band. It is employed to measure plant health and vigor.

This equation gives results between -1 and +1. A result close to zero indicates no vegetation on the crop whereas a result near to +1 means highest density of green leaves on the crop (Mogili et al., 2018). GPS module installed on drones provides the coordinates of captured pictures.

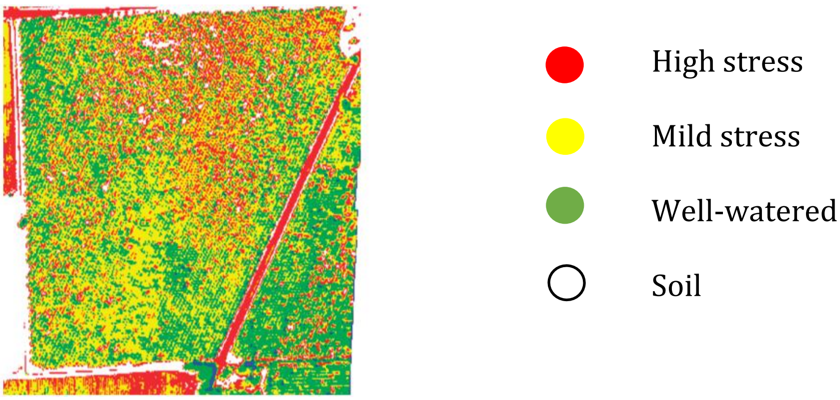


Fig. 2. Map developed from aerial pictures taken from a drone showing the health of a walnut orchard. Stehr (2015). *Drones: The Newest Technology for Precision Agriculture*, Nat. Sci. Educ. 44:89–91

Drones provides several advantages compared to satellites. First of all, they can monitor more often the field, they take more detailed pictures and they are not obscured by clouds. The 15-cm resolution of drone cameras is over 40.000 times better than the most commonly available satellite data and even 44 times better than the best commercial satellite images. Furthermore, drones don't need to rely on the satellite flight path so they can re-fly over some areas or move in for a closer look (Stehr, 2015).

UAVs provide also several advantages compared to conventional aerial vehicles, such as smaller size, lower weight, lower cost, lower flight speed and lower altitude. Last advantage is particularly useful because drones allow for a much more precise resolution. In fact, they can reach 0.01 m $pixel^{-1}$.

UAVs are cost efficient because they don't need on-board pilots differently from conventional manned aircraft. Consequently, pilot training, registration and airport fees aren't required.

In recent years, the use of UAVs in spraying operation has increased because of their speed, accuracy and the possibility to reduce the amount of pesticides and fertilizers. Generally, the sprinkling system is attached to the lower region of the drone. This system is made by a spraying content, a nozzle for spraying, a controller which activates the nozzle and a pressure pump that pressurizes the content to flow through the nozzle.

There are several agricultural drones available in the market:

- ❖ AgDrone System by Honeycomb company: it is a fixed wing drone produced by Honeycomb Company and it is considered the most sophisticated one as it covers 600-800 acres of field every hour, flying at 400 feet. Its maximum speed is 82 km/hr. It is suitable to all conditions and it's durable thanks to its wings. It is made by Kevlar Fiber composite which is the material used to produce bulletproof jackets.

Fig. 3. AgDrone System. Puri et al. (2017) *Agriculture drones: A modern breakthrough in precision agriculture*, Journal of Statistics and Management Systems, 20:4

- DJI Matrice 100: it is a fixed wing drone with intelligent flight battery. Its maximum speed is 5m/s (ascent) and 4m/s (discent). It's considered the best quadcopter drone for agricultural purposes in fact it has a dual battery support which guarantees 40 additional minutes of flight. It includes also a GPS system, a flight controller and an advanced navigation system that allows it to operate with temperatures between -10°C and 40°C.

Fig. 4.DJI Matrice 100. Puri et al. (2017) *Agriculture drones: A modern breakthrough in precision agriculture*, Journal of Statistics and Management Systems, 20:4

- DJI T600 Inspire 1 Quadcopter: it is made by carbon fiber materials. Special features include 4k video recording, individual flight and camera control.

Fig. 5. DJI T600 Inspire 1 Qadcopter. Puri et al. (2017) *Agriculture drones: A modern breakthrough in precision agriculture*, Journal of Statistics and Management Systems, 20:4

- Agras MG-1-DJI: it is an octocopter employed to spray large areas with pesticides, insecticides and fertilizers. It can carry up to 10 kg of liquid and it can cover 4000-6000 m2 area in just 10 minutes. Its maximum speed is 22 m/s and it can fly between 0°C and 40°C.

Fig. 6. Agras MG-1-DJII. Puri et al. (2017) *Agriculture drones: A modern breakthrough in precision agriculture*, Journal of Statistics and Management Systems, 20:4

- EBEE SQ-SenseFly: it is employed for the crop monitoring from planting to harvest. It is equipped with multispectral sensors able to capture data across four non-visible bands together with RGB images in just one flight. A RGB image is a picture which is digitally decomposed into three basic colours: cyan, magenta and yellow. In the agricultural field this is important in order to observe the health of the crop. It is compatible with Pix4dmapper AG mapping software to realize NVDI maps.

Fig. 7. EBEE SQ-SenseFly. Puri et al. (2017) *Agriculture drones: A modern breakthrough in precision agriculture*, Journal of Statistics and Management Systems, 20:4

- Lancaster 5 Precision Hawk: it is a fixed wing with a single electric motor. It is considered as one of the most autonomous drones; in fact, it adjusts by itself to payloads and environmental conditions. It is equipped with sensors like humidity, temperature, pressure and an incident light. It has different interfaces: analog, digital, Wi-Fi, Ethernet, USB. Its maximum speed is 79 km/h.

Fig. 8. Lancaster 5 Precision Hawk. Puri et al. (2017) *Agriculture drones: A modern breakthrough in precision agriculture*, Journal of Statistics and Management Systems, 20:4

- SOLO AGCO Edition: it is fully autonomous in flying and it provides high-resolution maps. It is equipped with two cameras: GoPro 4 Hero4 Silver and NIR GoPro. Its maximum speed is 55 mph and it can fly for 25 minutes. It is connected to Agribotix imaging and analysis software for precision agriculture.

Fig. 9. Solo Agco Edition. Puri et al. (2017) *Agriculture drones: A modern breakthrough in precision agriculture*, Journal of Statistics and Management Systems, 20:4

The most important manufacturers are: Honeycomb, DJI, Parrot, Precision Hawk and AGCO.

Drones serve many different agricultural purposes and more are being created every year. Their flexibility together with the number of additional features suggest they can be used for every agricultural application. Costs are getting more affordable and the legislation is adjusting itself. As a result, drones are becoming useful tools for agronomists and farmers.

Electromagnetic induction sensing of soil electrical conductivity for precision agriculture

In the past, grid-sampling techniques were employed to determine variations in soil nutrients. According to this technique, after samples had been extracted, georeferenced and analyzed, a map was developed by either filling in the grid cells with the soil test value (grid cell method) or assigning the soil test value to a point and then interpolating between points (grid point method). Anyway, several problems have risen. Sudduth et al. (2001) pointed out that there isn't a unique grid size suitable to all fields. Secondly, uniform grid can contain systematic mistakes due to fertilizer banding, terraces, uneven fertilizer application, continuous one-way row cropping, drains and a variety of environmental factors. Thirdly, the grid-sampling doesn't represent all the different soil types, but only an average of them. Furthermore, it has been demonstrated that this analyses provides information mainly linked to physical properties related to water rather than to soil nutrient status.

Bulk soil electrical conductivity (ECa) is a sensor-based measurement that can provide information about important soil properties. It's based on the ability of materials to transmit an electrical current and it is generally expressed in units of milliSiemens per meter (mS/m).
Factors that influence ECa include soil salinity, clay content, clay mineralogy, soil pore size and distribution, soil moisture content, temperature and cation exchange capacity (CEC) (Sudduth et al., 2001). Cation exchange capacity refers to the percentage of clay and organic matter. As this percentage increases, the CEC increases as well.
Grisso et al. (2009) demonstrated that the variability of saline soils is influenced by the concentration of soluble salts, whereas that of non-saline soils is a function of soil texture, moisture content and cation exchange capacity. Specifically, conductivity increases with soil moisture and clay soils. In fact, sands have a low conductivity, silts have a medium conductivity, and clays have a high conductivity because of their high levels of porosity.
Actually, the first application of electrical conductivity in agriculture was linked to the measurement of soil salinity.
Nowadays there are two types of sensors available on the market: contact and non-contact sensors. The information and the results provided are similar.
Contact sensors are made of three pairs of coulters which serve as electrodes. They make contact with the soil to measure the electrical conductivity. Two of the three pairs of coulters are mounted on a toolbar. One pair inserts electrical current into the soil, whereas the others (which are called receiving electrodes) measure the voltage drop between them. Data is recorded into a data-logger which is connected to a GPS system that provides information about localization. The toolbar can be pulled by a tractor or a track. This type of sensor is the most suitable for agricultural purposes because it allows to analyze large areas quickly and it is not influenced by external electrical interferences. The disadvantages are related to the fact that it's bulk and it is not suitable for small plots or fields.
Non-contact EC sensors are based on the principle of electromagnetic induction (EMI). EMI doesn't contact the soil surface directly. This tool is made of a transmitter and a receiver coil which are installed at opposite ends of the instrument. The device is equipped with a sensor that measures the resulting electromagnetic field induced by the current. The transmitting coil sends an electrical field into the soil and the ability to carry the electrical field is related to soil properties. The device must be mounted on a non-metallic car

or a vehicle to prevent interferences. Specifically, it's necessary to keep a distance of about 4 to 5 feet between the sensor and any metal object to avoid interferences.

Non-contact EC are more suitable for small areas because their weight is low and thy can be handled by a single person.

EM38 and GEM-2 are two models of non-contact sensors. The former is produced by Geonics Limited which is a company based in Ontario, world leader in the production of electromagnetic geophysical tools whereas the latter is developed by Geophex Limited that produces custom frequency-domain and time domain instruments.

GEM-2 is a digital, multi-frequency sensor which measures EC at different depths. EM-38 works only with a fixed frequency and it has an effective measurement depth of 5 feet in horizontal mode or 2.5 feet in vertical mode (Grisso et al., 2009).

EC analysis allows farmers to know soil properties. Consequently, they know the different quantities of nutrients and fertilizers they have to spread in the different areas of the field. Anyway the correlation between conductivity and crop production input is not linear, so they have to take into consideration also soil sample data, historical productivity and local agronomic knowledge. For instance, EC analysis sometimes indicates high levels of clay and CEC and consequently more inputs are needed in these areas. On the other hand, in other areas higher conductivity indicates excessive clay, that limits production and reduces the input required. Soil EC maps helps to know how to manage (Grisso et al., 2009):

- Variable seeding and nitrogen rates based on site-specific yield goals based on CEC levels;
- Variable seeding rates based on the depth of topsoil;
- Variable soil-applied herbicide rates based on organic matter, texture and CEC;
- Variable lime rates based on zone sampling according to CEC levels;
- Limit applications of gypsum to sodic areas.

Anyway, it's necessary to pay attention because EC maps may be unreliable. EC measures are unreliable after the application of high rates of manure or bio solids as they contain salts. Extremely dry soils may also lead to wrong readings. Avoid making measurements when soils are dry to a depth of 30 to 40 cm as conductivity is significantly reduced and readings are more variable (Grisso et al., 2009).

Filtering machine

The filtering machine is employed in the wine firms to filter wine. The filtration is one of the most important phases of the process as it ensures great taste and absence of unwanted particles and substances.

A filtering machine is equipped with a filtering membrane which is made of a filtering substance that collects on a filtering core in a filtering tank and it is controlled by programmable logic controller (PLC). It can be used to filter any liquid: from water to wine. Based on the US patent registered in 1998, it is composed by several components. In the document, a machine to filter water is described but it works also with other beverages. It includes a raw water tank, a purified water tank, a primary debris strainer, a working pump, a filtering substance supplying tank, a filtering tank, a concentrated debris tank and a programmable logic controller.

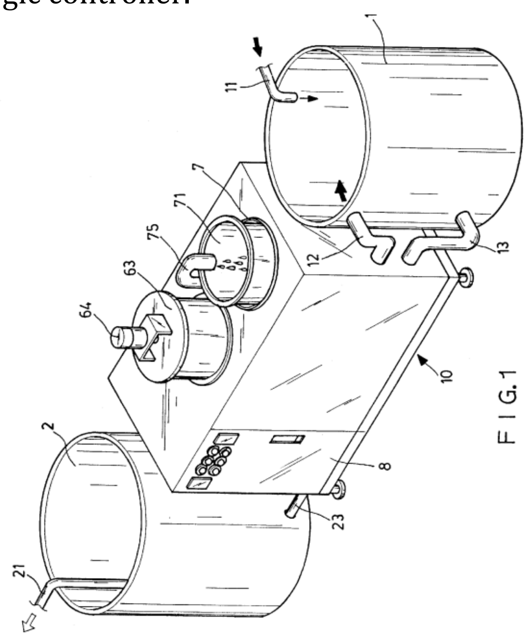


Fig. 10. Filtering machine. Chiang et al. (1998). *United States Patent 5,772,867*

1. Row water tank
2. Purified water tank
7. Concentrated debris tank
8. Programmable logic controller
10. Housing
11. Inlet pipe
12. Outlet pipe
13. Returning inlet pipe

21. Purified water outlet pipe
23. Retro-cleaning auxiliary inlet pipe
63. Hopper
64. Motor
71. Recycling cylinder
75. Recycling circuit

The raw liquid is drained out from the outlet pipe from the raw liquid tank and it flows over a check valve. The debris of larger size is firstly filtered by the primary debris strainer. After that, the filtered liquid goes through the solenoid, the working pump and the five-port-two-way valve and into the filtering tank. Specifically, the purified liquid flows over the five-port-two-way valve and into the purified water tank. The debris is accumulated on the filtering membrane and for this reason the liquid flow that can penetrate the membrane is limited and consequently the pressure within the system increases. As soon as the pressure reaches the exceeding level, the solenoid closes itself and the five-port-two-way valve is switched to the retro cleaning position. In this position, the water flow is drained through the auxiliary pipe from the purified water tank into the inner space of the filtering net core. The cleaning water together with the debris pass through the five-port-two-way valve and into the recycling cylinder of the concentrated debris tank through the recycling circuit. The quantity of the debris is controlled by two level controllers and the debris is filtered by a woven filter within the recycling cylinder (Chiang et al., 1998).

A filtering machine provides several advantages. Firstly, the wine appearance improves. In fact, it helps wine to have a crisper and clear appearance. Secondly, filtration reduces the time for aging because it allows to decrease the quantity of tannic acid and proteins. In addition, filtration can be used to lighten wine colours: some white, red and rose wine should be of lighter colour. Finally, accidental re-fermentation may occur when there are large amounts of yeast in bottled wine. Fermentation can decrease significantly the probability that re-fermentation happens.

The filtering membrane can be made by different materials: from plastics to ceramic. Ceramic membranes are the last one to have entered the market and they're the most technological ones. They are porous ceramics, which are formed from ceramic granules. These

granules are held together with binders until the incredibly high temperatures of sintering bind the ceramic granules and leave predictable porous openings in a uniform array. Ceramic membranes are sintered at high temperatures that make the filter inert.
They provide several advantages compared to other micro filters, such as: longer and reliable lifetime, cleanability, durability, chemical resistance to high pressure temperature, corrosion and abrasion. In addition, they are intensive to bacterial actions and they can be sterilised repeatedly.
Nowadays filtering machines are completely automated and they don't need operators all the time. Operators can manage and set the machine remotely thanks to an Android device connected to internet by means of the optional remote control module. Parameters can be set easily through a touchscreen interface.

Machine vision systems

Machine vision systems are useful tools employed in the agricultural field to assess resources, postharvest product quality and safety detection. They don't recognize only objects' shape, colour, texture, but they also provide numerical attributes. Their most important feature is that they're able to inspect objects in lights which are invisible to human eyes, such as ultraviolet (UV), near infrared (NIR) and infrared (IR).
Humans see visible light (380 nm to 700 nm), but there are two additional lights, which can't be seen by people. For example, goldfish see infrared (700 nm to 1mm), whereas bumble bees see ultraviolet (10 nm to 380 nm). Multispectral and hyperspectral imagery provides the opportunity to see red, green and blue, infrared and ultraviolet lights.
The main difference between multispectral and hyperspectral is in the number of bands and how narrow the bands are. Multispectral pictures refer to the range from 3 to 10 bands whereas hyperspectral imagery consists of much narrower bands (10-20 nm) and for this reason, the last one provides more detailed information because of its higher spectral resolution.
For agricultural purposes it's necessary to see even the unseen lights because they provide information about stress state, maturity, ripeness and diseases of plants. Furthermore, they're important to assess quality, defects, composition, functional properties of postharvest products. Machine vision systems are based on the idea that vegetation, food

and agricultural products are biological materials so they absorb light in different manners.
For what advantages are concerned, these systems allow firms to improve their productivity, reduce costs and to make the work much easier and safer for workers. Food is also guaranteed to be more safe and of higher quality.
They work by acquiring reflectance, transmittance, or fluorescence images of the agricultural materials under UV, VIS, or NIR illumination.
To be implemented, these systems need a camera, a computer equipped with an image acquisition board (frame grabber), a lightening system and a software to process images. The light range can be in the UV (200/400 nm), VIS (400/700 nm), or NIR (700/2500 nm). There are also applications in thermal imaging (above 2500 nm) for agricultural products (Chen et al., 2002).
As far as cameras, different models can be employed according to the need.
Monochrome cameras perform simple shape and size recognition tasks. They are employed for several purposes such as detection of blemishes and bruises on apples and to detect scars, cracks, and spreading tips for asparagus.
Multispectral cameras are employed to assess surface defects and diseases on meat, grains, fruits, and vegetables. Multispectral imaging consists of a set of several images, each acquired at a narrow band of wavelengths. The simplest method to obtain images at a discrete spectral region is by positioning a bandpass filter (or interference filter) in front of a monochrome camera lens. Multispectral images can be obtained by capturing a series of spectral images by using either a liquid crystal tunable filter (LCTF) or an acousto-optic tunable filter, or by sequentially changing filters in front of the camera (Chen et al., 2002).
The last technique to have been implemented is the hyperspectral imagining. This technique combines the features of imaging and spectroscopy to acquire both spatial and spectral information from an object. This technique can be used to extract chemical composition other than traditional information. Applications range from precision agriculture applications, such as detection of plant stress or crop infestation, to medical applications, agricultural product quality and safety sensing (Chen et al., 2002).
When the lightening system illuminates the object, the radiation can be absorbed, transmitted or reflected. The process of absorption and re-emission of light is called fluorescent. The imaging camera receive the light and it converts it into electrical signals using

charge-coupled device (CCD) which are silicon based devices. The electrical signals are proportional to the intensity of the light from the surface. An A/D device (which is a device that converts images from analogue to digital) converts the electrical signals into an 8 or 16bit data, and the digitized imaging data are then stored in the computer.

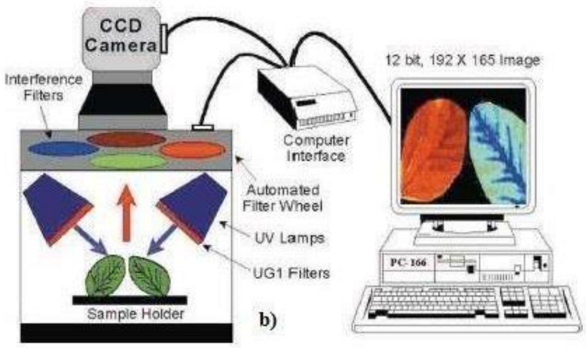


Fig. 11. Multispectral imaging system. Chen et al. (2002). *Machine vision technology for agricultural applications*, Computers and Electronics in Agriculture 36 (2002) 173-191

As pointed out before, a software is needed to process images. This process consists of three steps: image improvement, image feature extraction and image feature classification. Digital images need to be enhanced to solve problems related to poor contrast and noise. These troubles are generally corrected thanks to morphological operations, filters, and pixel-to-pixel operations. Statistical procedures as mean, standard deviation, variance, principle component analysis are employed to extract features from digital pictures. Once image features are identified, the further step is feature classification through numerical techniques such as neural networks and fuzzy inference systems.

Near Infrared Reflectance Spectroscopy

NIRS technology provides useful information to evaluate food and beverage quality. In particular, it is implemented to analyze the adulteration, identify nutrients and evaluate corn, meat, fruit, wine, dairy, oil and milk.

NIR spectroscopy bases on the absorption of electromagnetic radiation. It employs the spectral range from 780 to 2500 nm (12,500e4,000 cm^{-1}) and it provides information in relation to the vibration behaviour of combinations of bonds. In particular, molecular bonds OeH, CeH, CeO and NeH are subjected to vibrational energy changes when irradiated by NIR frequencies. Two type of vibration may occur: stretch or bent which give details about the varieties of molecules present in food and beverages.

Infrared light is passed through a sample and it can be absorbed or reflected. For example, transmittance is typical of cheese whereas reflectance is typical of milk. The absorption or the reflectance creates an infrared spectrum which provides information about the composition of products thanks to algorithms called calibration.
Anyway, not everything responds to wavelengths in the same way. There are some wavelengths which are better for measuring certain samples and parameters than others. The wavelength required to measure proteins in grain is different from that required to measure amino acids in feed ingredients.
A spectrometer tool is made of a light source, a beam splitter system which translates multi-colour light into single-colour one, a sample detector or chamber, an optical detector and a software to process data. Tungsten halogen lamps are frequently employed because they're cheap and they offer high intensity in the near infrared, anyway they have also several disadvantages such as a limited operational lifetime as well the fact that the spectral content of the output can drift with the time, and the radiant energy is not equal in different wavelengths. An alternative to halogen lamps are the LED ones but they're more expensive.
Cen et al. (2007) stated that the technique requires to follow several steps:

- Spectral data acquisition through the spectrometer instrument;
- Pre-processing data to eliminate noises and baseline shift from the instrument and background to obtain reliable models. There are different pre-processing methods, but the most common technique is smoothing that uses algorithms to compute a function that tries to capture the most important patterns in data, excluding noise.
- Building calibration models using a set of samples for qualitative and quantitative analysis
- Validation of the models using another set of samples without the calibration set

A recent trend is to make continuous measurements every few seconds. In this way, operators have more information and they can make corrective actions on time.
Analysing food quality through NIR spectrometry provides several advantages. First of all, it's a fast technique, so few seconds are required to make the analysis. Secondly, the measurement isn't expensive because it doesn't need particular materials to work, such as chemical reagents. This technique doesn't contain chemical substances and it doesn't damage products so samples can be used for other tests.

As far as the disadvantages, the major difficulty is building a strong and reliable calibration model. Because of the high number of samples, complex calibration and validation procedures must be performed before using the instrument. In addition, even if the measurement cost is low, the instrument is very expensive so a significant initial investment is required.

Remote sensing applications in agriculture

Remote sensing applications are based on the interactions of electromagnetic radiation with soil or plant material. They involve the non-contact measurement of reflected or emitted radiation from agricultural fields. The amount of radiations which are reflected depends on soil moisture as well as organic matter content, clay minerals, calcium and iron oxides.

These measurements are made from satellites, aircrafts, tractors and hand-held sensors. Measurements made with tractors or hand-held sensors are also called proximal sensing. These platforms and their associated imaging systems are different because of the altitude of the platform, the spatial resolution of the image and the minimum return frequency for sequential imaging.

As spatial resolution improves, the area of the smallest pixel decreases, and the homogeneity of soil or crop characteristics within that pixel increases. Poor spatial resolution implies large pixels with increased heterogeneity in soil or plant characteristics. The availability of remote sensing images from satellite and aerial platforms is often severely limited by cloud cover whereas ground based remote sensing is less affected by this limitation (Mulla, 2013).

They are employed to assess crop yield, biomass, crop nutrient, water stress, infestations of weeds, insects and plant diseases and soil properties such as organic matter, moisture, clay content and ph.

The first satellite for remote sensing was launched in 1972. It was called Earth Resources Technology Satellite 1 (Landsat 1). Landsat 1 collected pictures in the green, red and two infrared bands at a spatial resolution of 80 m and a return frequency of 18 days.

Several improvements have been made since 70s. One of the last development was the five-satellite constellation developed by the RapidEye. It provides daily coverage for any location on the globe, and it collects data with a 6.5 m spatial resolution.

In 2008, GeoEye launched a commercial satellite designed to provide services similar to RapidEye. GeoEye 1 satellite has a return visit frequency of less than three days, and it collects data from 40 to 60 cm spatial resolution in the blue, green, red and near infrared bands. One of the main uses for GeoEye 1 imagery is providing Google Earth maps that are available through the Internet.

DigitalGlobe launched the WorldView 2 satellite in 2009. It takes pictures at 50 cm resolution with a return frequency of one day. This last one is more advanced compared to the previous ones because it takes pictures in the standard blue, green, red, and near infrared bands, as well as bands in the purple (450e480 nm), yellow, red-edge and a second near infrared frequency range.

Fig. 12. WorldView 2 satellite. Picture from DigitalGobe website

It's possible to affirm that spatial resolution of imaging systems has improved from 80m to sub-metre resolution. Moreover, the return visit frequency has improved from 18 days to 1 day. Finally, the number of spectral bands available for analysis has increased from four bands (bandwidths greater than 60 nm) to eight or more bands (bandwidths greater than 40 nm).

Because of the limitations of satellite systems in precision agricultural field, proximal remote sensing techniques seem to be more useful. Sensors mounted on tractors, spreaders, sprayers or irrigation booms, allow real time site specific management of fertiliser, pesticides or irrigation (Mulla, 2013).

Site-specific fertilisation is one of the main objectives in precision agriculture. Variable rate application requires accurate and efficient tools to determine the actual nutrient demand. Remote sensing techniques offer the opportunity to deliver this information quickly, precisely and cost-efficiently.
In 1996, Stone et al. measured spectral radiance in the red (671 nm) and NIR (780 nm) bands in wheat with a sensor mounted on a mobile lawn tractor. They used this data to estimate the plant nitrogen spectral index (PNSI), which is the absolute value of the inverse of NDVI. Results showed that PNSI was strongly correlated with crop nitrogen uptake. Sensor readings were used to change nitrogen fertiliser rates using an algorithm that increased exponentially with PNSI values. Thanks to this discovery, the first technology to apply the right amount of nitrogen at the right place and at the right time was developed. Its commercial name was GreenSeeker NDVI active sensor and it was marketed by NTech Industries in 2001(Mulla, 2013). This sensor allows to optimize yield and nitrogen input expenses. Specifically, testing has proven that GreenSeeker generates from $8 to $10 average return per acre on winter or spring wheat, and an $18 per acre average for corn.

Fig. 13. GreenSeeker sensor. Image retrieved from https://www.pioneer.com/home/site/us/agronomy/library/sensors-to-improve-corn-nitrogen/

Anyway, other sensors have been developed over the years to adjust the fertiliser application rate. In 2002, Reusch, Link, and Lammel developed a tractor based passive sensor to determine crop nitrogen status based on NDVI. This sensor is known as the Yara-N sensor. It provides several advantages, such as: bringing the optimal fertiliser rate in every part of the field, enhancing crop potential all over the field, increasing fertiliser efficiency, decreasing nitrogen residues in soils post-harvest, reducing harvest time and costs, reducing risk of nitrogen losses to the environment and allowing quality to be more homogeneous.

Fig. 14. Yara-N sensor. Picture retrieved from https://www.agricon.de/en/n-fertilization/features/

In 2006, it has been developed also a version equipped with active sensors. This last one is better because errors due to varying cloud cover are less and it allows to work also at night. It is called ALS sensors (Active Light Sensors). The main difference compared to the previous version is that it has its own light source (it is equipped with Xenon flash lamps) so it can work independently from environmental conditions.

a b

Fig. 15. Yara-N sensor (a), ALS sensor (b). Picture retrieved from https://www.agricon.de/en/n-fertilization/features/

Another sensor which works independently from environmental conditions is the Crop Circle ACS-430 active crop canopy sensor. It has three optical measurement channels. The sensor measures crop and soil reflectance at 670 nm, 730 nm and 780 nm simultaneously. It can be mounted on any agricultural vehicle and it provides information about nutrients, water, disease or other growing conditions on plants or crops. It is connected to a software which allows to record data to a text file or on a SD card. A GPS receiver can be connected to it, so data can be georeferenced.

A limitation of these sensors is that they can't estimate the amount of nitrogen fertilizer needed to overcome crop nitrogen stress. Nowadays reference strips are still necessary to estimate crop deficiencies directly.

Fig. 16 Crop Circle ACS-430. Image retrieved from http://agreng.agr.uth.gr/node/42

Several improvements have been made concerning remote sensing. Anyway, additional efforts are needed to develop new indices that give simultaneous information about crop characteristics and stress as well as new approaches which provide customized management of farm input for individual plants. Furthermore, Mulla (2013) stated that historical archives of satellite remote sensing data should be integrated with real-time remote sensing data to take better decision in precision agriculture.

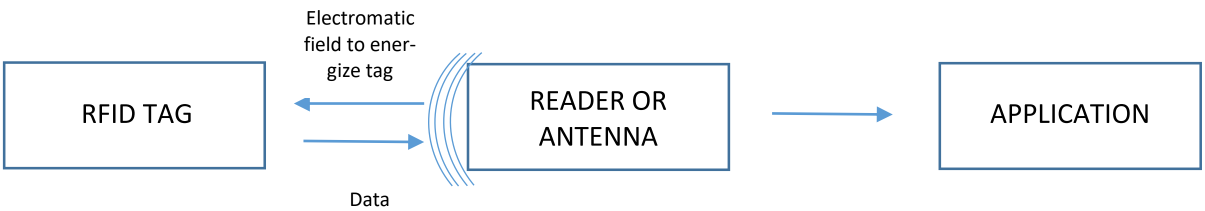
RFID Technology

Radio Frequency Identification is a technology which provides information about the traceability of products by identifying or tracking them. This technology has recently become very popular because of its advantages. First of all, it uses simple and cheap components. Secondly, it avoids manual control. In addition, it is versatile and it can be used in very different contexts, as it is long life, water-proof, antimagnetic and suitable to many different temperatures. Finally, the storage capacity is big and stored data can be modified, consequently mistakes can be corrected.

It is substituting bar-code and QR-code technologies. Compared to those technologies, RFID allows faster information flow and it's less expensive for companies because less labour is needed to tag and read.

Its architecture is composed by a RFID tag, a reader which can be either an interrogator or an antenna and a data base system used to store the information acquired.

RFID tags are small pieces of material including an antenna, a microchip and an encapsulating material of different shapes. They can be embedded in materials such as glass or epoxy resins.
They are characterized by an identification code known as the Electronic Product Code of 96 bits. If the tag is a read-only one, stored information can' be modified or erased. On the other hand, in a read-write tag, stored data can be modified, written or manipulated.
Their memory capacity varies from 12 to 32 KB. They can be put inside products or containers because they don't require line-of-sight with the reader, differently from bar-code.
Tags can be active, passive or semi-passive. Passive tags provide information only if they're powered by the reader. In this case they reply to the interrogator using the backscatter technique. They do not have any power supply. They get their power from the incoming radio waves from the reader. The active ones are equipped with a battery and they are able to transmit independently from the powering field of readers. They're better because the transmission can cover larger distances from the reader and because they have a power source for their internal circuitries and for sending the response to the reader. Semi-passive tags have a power supply for internal circuitries, but for sending the response they rely on the radio waves received from the reader.
It's possible also to combine both RFID technology and bar-code. Smart labels are an example as they incorporate both of them. They're made of an adhesive label embedded with an RFID tag inlay, and they may also feature a barcode and other printed information.
Tags send information to the reader trough radio waves. They are then translated into more understandable data and transferred to a computer system.



Costa et al. (2012) suggested that RFID technology can be integrated with geostatistics to optimize decisions about supply chain and logistics. Web-based tracing systems improve products quality by increasing the level of information transparency for consumers. This is achieved by collecting scientific and productive information.

The subject categories involved are manufacturers, wholesalers, resellers, retailers and finally consumers. The implemented web software is structured to provide various services to all the categories thanks to the Application Programming Interface (API), which allows different subjects of the production and supply chain to implement the acquisition and/or writing system following their needs and available technologies and ensuring uniformity of data to consult or send.
Info tracking systems can also provide a reference web interface to access the product info card displaying all information and data released by the manufacturer, wholesaler, reseller and retailer. In particular, consumers have the possibility to check all the info concerning the products they had bought. They can do it by using the RFID reader provided by their retailer or reseller, through the web or through smartphone applications. This system allows them to provide their feedback about products' quality.
The implementation of RFID technology to meat production and supply is particularly difficult because the control has to be extended to living animals. EU policy imposes the uses of specific RFID technology for meat traceability and different studies have been carried out by many authors.
Tomeš et al. (2009) wrote about the implementation of RFID to identify cattle sample by associating each ID with a whole set of biometric identifiers to allow the correct identification of meat sold units with the animal of origin.
Kong et al. (2009) implemented the RFID system to identify animals in pig farms and then this data was organized into a database.
As reported by Kerry et al. (2006), at present, individually RFID tagged meat products are not available to consumers, although the use of RFID tagging of meat cuts has extended, in one case at least, to the pig processing industry from the individual pig to its primal pieces, (i.e., hams).Although the purpose of this tracking scheme is for quality control, employee accountability and precision cutting, and does not extend beyond the cutting room floor or provide information about the individual animal with the final product, it does exemplify the developing use of RFID technology within the meat industry.
As far as dairy products, safety and traceability are important concerns. After the Sanlu milk scandal occurred in China in 2008, the government promoted the use of dairy cattle radio frequency identification techniques to strengthen tracking systems.

Cai and Liang (2011) used RFID technology to track the movements of milk packages ensuring information transparency. Thanks to them, consumers could have real time information through internet applications.

In Europe few researches have focused on this issue. Pérez-Aloe et al. (2007) tested different RFID applications regarding cheese traceability based on two different types of tags. Lecture trials were carried out considering different condition (i.e., temperature, humidity, corrosive or saline solutions immersions). No significant negative effects on tags readability were reported, with the exception of those cases where metallic materials occurred in the range of the reader.

Varese et al. (2008) implemented the technology not only for tracking reasons but also to avoid the imitation of the PDO. They used two tags, one which was inserted inside the cheese at the end of the forming process and the other one that was external as it was put in a casein plate. Their study has demonstrated that the position of tags doesn't affect readability.

Papetti et al. (2012) focused both on traceability and quality. They developed a platform which provides both information. Producers, wholesalers, retailers, resellers and consumers can contribute to the centralized database by adding information.

Fishery is a high perishable food category and for this reason traceability is even more important in this type of industry. The temperature is one of the most important factors influencing the quality of seafood. In this context, Mc Carthy et al. (2009) and Liu et al. (2010) proposed to implement RFID technology together with other detectors, such as iButtons and Time Temperature Indicators (TTIs). IButton is a sensor made by a computer chip enclosed inside a small steel can. It is used to measure temperature and humidity.

As far as beverages are concerned, Bernardi et al. (2008) analyzed a case study to evaluate the implementation of RFID technology to avoid counterfeiting of wine bottles. This system includes a passive RFID internal memory and unique RFID reader to allow the reseller and the final user to verify if the bottle is original.

Bhattacharyya et al. (2010) developed a system to measure the liquid level in commercial beverage glasses and bottles to ensure standardization. Specifically, the tag was used to detect the liquid level by mapping a change in received signal strength indication power.

As far as other food products, Singh et al. (2007), developed a RFID technology to provide information about traceability and quality of eggs.

Robotics

Robots have been employed since ancient periods. The first ones were robotic clocks based on the movement of water. In Greece, the first robotic pigeon was built in 420 B.C. It flew thanks to a stream of air. Aristotele dreamt a world in which every tool humans work with, could work on its own to reduce slavery. In the following years, between 500 B.C. and 200 B.C., Greeks developed many "automatae" driven by streaming water. Ticking clocks and machines with complex designs and connections were developed during the Medieval period in Arabia and China. The first robot similar to a human was developed by Leonardo Da Vinci in 1495. Artificial flying eagles were presented in Germany in 1533. They were the pioneers of the current drones. During the XVIII century, Japanese inventors developed different model of puppets and automatic moving toys known as 'Karakuri-ningyo.'

The development of the human robot known as Android was initially tried in Germany in 1727 but it was Jacques Vaucanson who built the first Android in 1738. It was impressive because it was able to play the flute by its own. After this invention, Frederich von Knauss developed an Android able to keep a pen with its hands and to write until hundred words. The development of robots improved a lot thanks to new technologies and knowledge especially over the last five decades. The first numerically controlled machine was built in 1952. Several projects were carried out at the Rockefeller Foundation and the first robot in charge of replacing difficult and dangerous tasks for humans was installed at General Motors Inc. During 1990s, several types of radio controlled and computer programmable gadgets and combat robots were designed and tested in the USA and Europe (Krishna, 2016).

As far as agricultural robots, they have been unsuitable for the purposes for many years as they weren't able to perform several tasks in farms compared to humans. The delay in developing agricultural robots was due to the difficulty in designing and constructing safe, reliable and easy-to-operate robots. Furthermore, the easy availability of human labour dissuades many from even thinking about robotics in crop production. (Krishna, 2016).

Agricultural robots started to be developed during the last century. The first generation robots were developed during 1980s and they were useful in scouting within the crop fields. They were autonomous or at times guided through remote control systems. They were equipped with cameras to detect crops and weeds. Over the years, sophisticated sensors that detect occurrence of drought, nutritional deficiencies or pest occurrence have been added to them.

The second-generation of agri-robots appeared in the 1990s and they were able to scout, identify and locate the crop, fruit or weed thanks to cameras and sensors. They were also able to accomplish tasks like weeding using plant cutting arms or small sprays of herbicides. They were also able to spread insecticide sprays and fertilizer supply. In some cases, the robots were connected to GPS guidance system that adds accuracy to robot's movements in crop field and the tasks they perform.

The last generation of agri-robots appeared in 2002 and they were able to accomplish tasks autonomously. This type of autonomous robot was developed thanks to a research carried out by Monsanto Company's Farm in 1957. This generation of robots includes autonomous movement, vision controlled identification, location using GPS connection, grasp and detachment of fruits or rapid grain harvest, grading and separating of products (Krishna, 2016).

Anyway, technology is improving and future robots will be able to perform additional tasks in the next years. For example, researchers think that driverless tractors and robots will be employed to pick up and grade fruits in Germany. In Australia, robots will able to handle farms, increasing productivity.

Agri-robots are employed mainly in land preparation, ridging, making channels, spraying liquid fertilizers, spraying pesticides, sprinkling irrigation water and in harvesting grains or picking fruits. Robots are used when repetitive, hard labour and drudgery is essential to achieve results (Krishna, 2016).

An example of agri-robot is Bosch Bonirob which is able to automate and speed up analysis. The robot, which is approximately of the size of a compact car, uses video and lidar-based positioning as well as satellite navigation to find its way around the fields. It knows its position to the nearest centimetre. It also helps to minimize the environmental impact of crop farming.

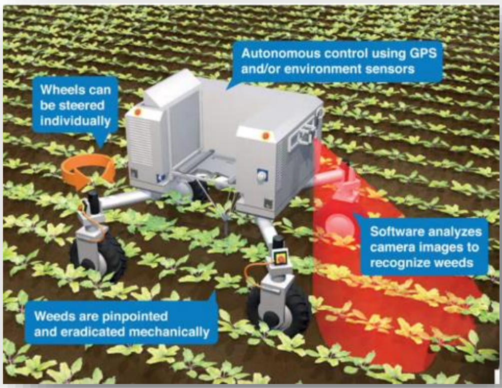


Fig. 17. Bosch Bonirob. Image retrieved from Bosch

The advantages provided by agri-robots are many. Firstly, they are able to perform tasks without drudgery in any season of the year. Secondly, they are the best choice to do timely operations in a large scale and to avoid mistakes and inaccuracy. As a result, healthier food and beverage is offered to customers as excessive accumulation of nutrients or microbes is avoided and soil properties are estimated correctly.

However, computer programs which guide robots should be tailored precisely because otherwise they lead to large errors.

In Nordic countries, such as Denmark and Sweden, robots are also employed to take care of dairy cattle. In addition, agricultural robots that harvest products, carry low amounts of microbial contamination so they are considered to pollute less the environment.

Self-driving vehicles

A self-driving vehicle is the one which can move without human intervention. It is equipped with a system capable of interpreting sensors to recognize route path and obstacles. Researchers on automated driving systems have been carried out since 1920s and trials started in 1950s.

SAE International (Society of Automotive Engineers is a US organization which establishes standards for professional engineers in many industries) published a list of six levels of driving automation, from no automation to full automation. It is called: J3016_201806 taxonomy and definitions for terms delated to driving automation systems for on-road motor vehicles. The levels are the following:

- Level 0: the vehicle provides warnings and it can temporarily intervene but the automated system can’t control the vehicle by itself
- Level 1: the automated system and the driver have together the control of the vehicle
- Level 2: the automated system has full control of the vehicle as it can accelerate, decelerate or stop it. The driver must pay attention and he can intervene at any moment
- Level 3: the automated system has full control of the vehicle but the driver can’t do other things in the meanwhile such as watching a movie. The system is projected to intervene also in case of emergency
- Level 4: no driver attention is required but the vehicle can drive only in georeferenced areas or special circumstances like traffic jams
- Level 5: no human intervention is required

Soltz (1972) affirmed that a fully automated vehicle moves along a path thanks to controllable means which are in turn under the control of command codes that are sensed at various sensing stations by a code sensing system along the path.

Google has recently designed a self-driving car which isn’t equipped with wheel for steering, brake or accelerator, on the contrary it has just buttons to start, stop, pullover and a computer screen to show the route. It navigates thanks to a GPS system and Google Maps. This innovation could be very interesting for companies because driverless tractors or vehicles may be implemented to move articles among warehouses or different factories, saving costs and time.

Dethe et al. (2016) explained that the driverless Google car is equipped with three constituents: Google Maps, hardware sensors and artificial intelligence. Hardware sensors are needed to represent the external environment as they were human’s eyes. They are: Lidar, Video Camera, Position Estimator, Distance Sensor, Aerial and Computer.

Lidar is a sensor developed to avoid obstacles. It is an optical remote sensing technology which computes the distance to the target by lightening it with a pulsed laser light. It is made by a laser, a GPS receiver and a scanner. It is mounted on the roof and it provides detailed 3D maps of the surrounding environment.

The video camera is positioned near to the rear-view mirror and it behaves as a driver. In fact, it has to detect traffic lights, pedestrians and other motorists.

The position estimator is called Wheel Encoder and it's an ultrasonic sensor which is mounted on the vehicle's rear wheels. It is needed to track position and movements of the car relative to the 3D map.
Distance sensors or Radars are four sensors which are mounted on both front and rear bumpers. They need to see nearly obstacles and to drive when there is traffic.
Aerial sensors capture information provided by GPS. They are needed because information given by the car's on-board instruments (e.g. tachometers, gyroscopes) are combined with localization information.
A computer is needed to combine all the data provided by the different sensors which are connected to an artificial intelligence software that provides the car with real time decisions. For instance, data is detected by sensors, it is then sent to the computer for the processing and then artificial intelligence takes decisions such acceleration, steering wheels and stopping.
At the moment, self-driving vehicles could be implemented for transports within companies' property. This means they are not required to interact with other vehicles or traffic. Anyway they must be able to detect obstacles and to follow a route path without making mistakes.

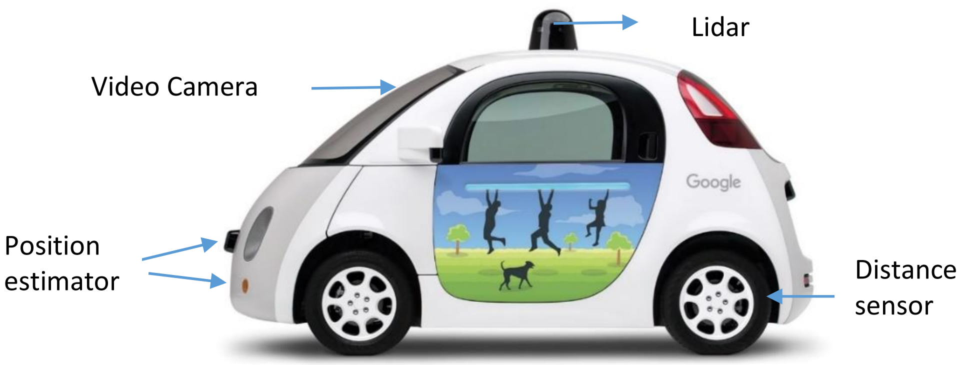


Fig. 18. Google self-driving car. Dethe et al. (2016). *Google Driverless Car*, IJSRSET, Volume 2, Issue 2, Online ISSN: 2394-4099. Themed Section: Engineering and Technology

Companies can decide to map the entire factory and then developing some fixed route paths. This is particularly useful when cycle timing is critical and the environment doesn't change rapidly. Differently, they can set sensors which provide information about the traversable areas and vehicles determine their own position and plan their movements dynamically taking into consideration features recognized in the environment.

Information about the position of vehicles is particularly important. Consequently, many approaches to identify it have been developed. A commonly used methodology is to rely on odometry augmented by sensor-based measurements from lasers, radio-frequency identification (RFID) systems, two-dimensional bar codes (e.g., QR codes) and cameras (Shneier et al., 2015).

More advanced systems use algorithms which allow to compute localization and navigation at the same time. They are called SLAM algorithms (Simultaneous Localization and Mapping) and they put together all data detected by sensors mounted on vehicles and they combine it with the position of the vehicle to build a map.

Shneier et al. (2015) pointed out that localization and navigation of commercial Automated Guided Vehicles is still commonly accomplished by wire guidance where induction is sensed from electrified wires embedded in the floor. Other common methods to move within a factory include: floor markers or magnets, laser triangulation, ceiling mounted bar codes or following a magnetic tape.

Anyway planning and coordination is fundamental because many aspects should be considered. Paths of different vehicles mustn't intersect, traffic shouldn't become congested and material must be delivered to the right place at the right times.

Coordination is usually achieved centrally, through centralized computation. Anyway, in less structured environments and situations, plans are not developed centrally, but the working place is divided into sectors and plans are developed at the sector level. An algorithm is employed to find paths from sector to sector.

As far as advantages, self-driving vehicles allow to boost productivity, decreasing time and saving costs. Anyway they should be checked frequently because they can damage places, goods and humans.

List of papers of technology applications on agri-food products

Technology	Paper	Reference
Agricultural Decision Support Systems	• Satellite Farming - Springer Nature Switzerland AG (chapter 13: Decision Support System for Precision Farming) • Agro DSS: A decision support system for agriculture and farming. Computers and Electronics in Agriculture (2018)	L. Ahmad, S. S. Mahdi (2018) Rupnik R. (2018)
Automated Warehouse	• United States Patent 5,568,393	Ando et al. (1996)
Drones	• Review on Application of Drone Systems in Precision Agriculture. Procedia Computer Science 133 (2018) 502–509 • The Rise of the Drones in Agriculture. EC Agriculture 2.2 (2015): 325-327 • Agriculture drones: A modern breakthrough in precision agriculture. Journal of Statistics and Management Systems, 20:4, 507-518 • Drones: The Newest Technology for Precision Agriculture - Natural Sciences Education, volume 44 • The application of small unmanned aerial systems for precision agriculture: a review - Precision Agric (2012) 13:693–712 • Approximate georeferencing and automatic blurred image detection to reduce the costs of UAV use in environmental and agricultural applications. Bio system engineering 151 (2016) 308 - 327	Mogili et al. (2018) Veroustraete (2015) Puri et al. (2017) Stehr (2015) Zhang, Kovacs (2012) Ribeiro Gomez et al. (2015)
Electromagnetic Induction sensing of soil electrical conductivity for precision agriculture (ARP system)	• Precision Farming Tools: Soil Electrical Conductivity - Communications and Marketing, College of Agriculture and Life Sciences, Virginia Polytechnic Institute and State University • Accuracy issues in electromagnetic induction sensing of soil electrical conductivity for precision agriculture. Computers and Electronics in Agriculture 31 (2001) 239–264	Grisso et al. (2009) Sudduth et al. (2009)
Filtering Machine (By pass filter machine)	• Improvement of wine crossflow microfiltration by a new hybrid process. Journal of food engineering 79 (2007) 1329–1336 • The use of multi-objective optimization to improve wine filtration. Journal of food engineering 58 (2003) 311–316 • Ceramic membranes: a robust filtration alternative	Salazar et al. (2006) Gergely et al. (2002) Finley J. (2005)
Machine Vision Systems	• Machine vision technology for agricultural applications. Computers and Electronics in Agriculture 36 (2002) 173/191	Chen et al. (2002)
Near Infrared Reflectance Spectroscopy (Safetypack)	• Theory and application of near infrared reflectance spectroscopy in determination of food quality. Trends in Food Science & Technology 18 (2007) 72- 83	Chen et al. (2007)
Remote sensing applications	• On-the-go soil sensors for precision agriculture. Computers and Electronics in Agriculture 44 (2004) 71–91 • Twenty-five years of remote sensing in precision agriculture: Key advances and remaining knowledge gaps. Bio systems engineering114(2013) 358 -371	Adamchuk et al. (2004) Mulla D.J. (2011)

	• Using High-Resolution Airborne and Satellite Imagery to Assess Crop Growth and Yield Variability for Precision Agriculture. IEEE, Vol. 101, No. 3 (2013)	Yang et al. (2012)
RFID Technology (Online traceability)	• A Review on Agri-food Supply Chain Traceability by Means of RFID Technology. Food Bioprocess Technol (2013) 6:353–366	Costa et al. (2012)
Robotics	• Push button agriculture: robotics, drones, satellite-guided soil and crop management. Apple Academic Press, Inc.	Krishna K.R. (2016)
Self-driving vehicles	• Google Driverless Car. IJSRSET, Volume 2, Issue 2, Print ISSN: 2395-1990. Online ISSN: 2394-4099 Themed Section: Engineering and Technology	Dethe et al. (2016)

CHAPTER IV

In order to study the consequences of technology implementation within Italian agri-food companies, I selected six companies from different sectors. Astoria and Berlucchi & C. are wine producers located in two different Italian regions: Veneto and Piedmont respectively. Società Agricola Porto Felloni is an agricultural company located in Emilia Romagna which produces different cultivations, from corns to tomatoes. Oleificio Zucchi is a company located in Lombardy which produces different types of oil. Latteria di Soligo operates in the dairy sector by producing cheeses and milk and finally Res Uvae is a demonstrative agricultural company based in Emilia Romagna. The last one is a particular firm because its mission is testing the most interesting and innovative solutions available in the market.

Most of the companies analyzed are small or medium sized, family owned enterprises. It was a choice not selecting large companies because I wanted to concentrate my study on the firms that characterize the Italian Industrial context.

I developed the cases by interviewing the owners, the employees and the technicians working at the selected companies. My goal was to find out why they decided to invest in advanced technologies, the changes involved and the impact these changes would have on their businesses future. I was also interested in the advantages and the difficulties met in the implementation process.

Interviews were made either by phone or at the company headquarters and they lasted approximately two hours. Some entrepreneurs allowed me to enter their offices, talk to employees, look at technologies and test products.

In order to collect more data and to examine better some business cases, I had to interview twice technicians or entrepreneurs working at the selected companies.

During the interviews, I took notes and I recorded voices to avoid missing data and information. Only in one case I didn't record because the entrepreneur didn't allow me. After the interviews, I listened to the recordings and I copied down questions and answers. Thereafter I added information found on other documents, given by companies themselves or downloaded by their websites.

In the following paragraphs, each business case is described in detail. Data presented have been collected by interviews, annual balance sheets, firm's websites and AIDA website.

List of selected companies

	Establishment Year	Turnover (2017)	Employees (2017)	Activity Description
Astoria S.R.L.	1985	€49.715.163	57	Table wine and q.w.p.s.r. production
Società Agricola Porto Felloni S.S.	1975	------	-------	Production and distribution of tomato, green beans and peas to processing industries, through producer organizations. Production and distribution of corn to dedicated industries. Production and distribution of wheat to mills.
Latteria di Soligo S.C.A.R.L.P.A.	1883	€71.828.687	141	Production, processing and distribution of the milk supplied by the associated companies
Oleificio Zucchi S.P.A.	1946	€200.622.295	131	Production and refinement of vegetable oils.
Res Uvae S.R.L.	2015	€150.436	3	Growing of grapes
Berlucchi & C. S.P.A.	1981	€39.922.612	101	Winemaking, and production of wine products, sparkling wines and specialised wines as well as production of alcoholic drinks in general

Astoria

It was founded in 1987 by Paolo and Giorgio Polegato. Even if it is a relatively young company, the Polegato family has always been active in the world of wine. In fact, before Astoria was founded, the family sold wine carafes with a cart in Valdobbiadene and then Astoria started to sell wine bottles in Ho.re.ca (Hotellerie-Restaurant-Café) channels.
Astoria wines are produced in the company vineyard "Tenuta Val De Brun" in Refrontolo, in the heart of the DOCG Conegliano - Valdobbiadene area. The best known wine produced by the company is Prosecco. Thanks to this wine, Astoria has won many awards over the years, including the Grand Gold Medal at the Vinitaly International Wine Competition in Verona. Prosecco Millesimato Docg and Refrontolo Passito Docg represent the jewels of the firm. But Astoria is not only Prosecco, it also produces barrique wines including Colli di Conegliano Docg Crevada and Croder.
Astoria products are present in the most exclusive catering as well as wine bars. The company has made a business decision not to sell its products in large distribution channels. In order to sell in that market, it’s important to have large warehouses, and the company has limited space. Its store, together with wine cellars are in Crevada, near Refrontolo, where the vineyards are located, while the company offices are in Crocetta del Montello, together with the warehouse and the production plant.
Astoria is the largest private winemaker of DOCG Prosecco of Conegliano Valdobbiadene, with a turnover of over 50 million euro, 55 thousand quintals of grapes vinified every year and around 60 employees. The turnover of the company is continuously increasing, demonstrating the effective strategies put in place by the owners.

	2012	**2015**	**2017**	**Variation %**
Turnover	€ 29.992.941	€ 46.353.348	€ 51.420.867	71,44%

At the sales level, Astoria sells 60% in Italy and 40% overseas. It exports to 90 countries; its first export market is the USA, followed by other European countries. In America the success of Prosecco is linked to the happy hour, a habit that is not widespread or that is linked to cocktails.

The marketing department has always been important within the company. Originally the design of the bottles was very simple, almost spartan, linked to rural tradition. The company's attention to marketing resulted in the launch of the first 'blue bottle' in the nineties. This was a choice that went against the trend. The company is also Giro d'Italia sponsor, a decision which has improved the firm's reputation and provided worldwide exposure for the brand. In an interview, Mr Giorgio Polegato[1] has explained that it is important to link the brand to positive situations as it conveys the idea that its products are reliable.
The commercial network is also fundamental: Astoria has 150 agents all over Italy, working in the competitive catering market.

Technologies implemented in the wine cellar

According to the Astoria oenologist Mr Roberto Sandrin, the evolution in wine cellars is almost at the PC level, every 6 months there are some innovative solutions, new methods, and new technologies to be implemented.
Speaking strictly about wine, the main innovation was the 360-degree introduction of software packages that allow the digital control of every aspect of the winemaking process.
Ten years ago there were analog filters, operators worked with material filtration supports and they did everything manually. A lot of consumables were used and as a consequence there was much more waste.
As far as filters are concerned, in the past flood filters were employed. They needed fossil flours used as a filtering layer. The operator filled the filter with flour and fitted the pre-panel. All manual work was controlled by the operator's experience without control systems. The laboratory checked the final result and if necessary it adjusted it, but 80% of the operations were dictated physically by operators.
In the last years these filtering tools have disappeared, partly because of processing waste and the problem of waste disposal. These have been replaced by membranes which don't

[1] Munari E., (2017 April 7). Da Refrontolo ai mercati di tutto il mondo: Giorgio Polegato di Astoria Vini nella redazione di Qdpnews.it. Qdpnews.it. Retrieved from https://www.qdpnews.it/pieve-di-soligo/15438-da-refrontolo-ai-mercati-di-tutto-il-mondo-giorgio-polegato-di-astoria-vini-nella-redazione-di-qdpnews-it

produce waste like filters because they are replaced once a year. The membrane has a much more delicate filtration system and the entire process is controlled by software.
In the past the company used polypropylene membranes, then it moved towards other plastic materials, while recent ones are in ceramic materials. These last ones have been experimented for many years but they have become widespread in the last years. Ceramic is much more resistant and it produces no waste differently form polypropylene membranes. The last filter was bought 4 months ago by the company.
Operators no longer do somethings by hand. In the production process area, the greatest innovation was the introduction of the filtering machine. The replacement of the filtration methods was made to increase production capacity. Following the replacement, there was the need to manage the process through software to avoid mistakes and damage. In fact, using the old systems, if operators made mistakes with the pre-panel, they threw away 20 kg of flour (with a value of 20 euro). Nowadays, if operators don't follow the software instructions and damage the membranes, the membranes cost from 50 to 80 thousand euro to replace.
Nowadays it is possible to manage the whole filtration process via machine: it is the machine which warns "I can filter up to here", "if you want more limpid wine I can't do it, "be careful because the filtration is raising the temperature". In this way the machine begins a dialogue with the wine.
The machine is called a by-pass filter machine and it is equipped with everything: filters, sensors and so on. It's necessary to put the wine to be filtered inside and the machine works by itself. Obviously it needs water, electricity, some pressure, but inside it has sensors and instruments that allow it to filter the wine and provide information on the wine situation at any time: temperature, pressure, turbidity. The operator is needed to turn the machine on and to attach the hose. The difference is that before the operator had to check the filtration process frequently: every half hour the operator had to check the presence of adjuvant. Today, if there are non-conformities, the machine stops itself and triggers the alarm. Only in this case the operator has to go to the machine and check what happened.
The big advantage is that this machine works at night, with the previous system this was not possible. Working at night means energy savings because electricity costs less at night. There is also an advantage from a production point of view. In the evening, the operator turns it on and he sets what the machine has to do: filtering the tank, filtering only half of

the tank, filtering some hectolitres. In the morning the operator finds the work done together with a report to download, even on USB key: the report provides information on the situation minute by minute. For example, at minute x the pressure was 300, the temperature was 30 and 50 hectolitres have been already filtered. If during the night, there is a pressure drop the machine stops and in the morning the software indicates what the problem was and the operator has to solve it.

Another advantage is that everything is documented. This is important from the quality point of view but also to guarantee standards: it's fundamental that all the wine is filtered and prepared in the same way.

According to the oenologist Sandrin, the largest innovation was the filters' evolution and the need to implement software. This is the most important evolution which has occurred in the production process, because in the other phases, including fermentation, the evolution is from a microbiological point of view as it involves new activators or adjuvants.

The filtering process is one of the most important processes for a firm which sells wine in bottles. Anyone who sells wine in tanks doesn't have these troubles and it doesn't even need filters. In Astoria's case, the filtering process is long and delicate and if unsuitable equipment and materials are used, quality can be lost. For this reason, this phase is the most affected by technological innovations.

As far as primary fermentation, the most important parameter to take into consideration is the temperature. In fact, one of the main concerns is the possibility that the qualitative characteristics of the wine are modified during its conservation as the product is very sensitive to variables such as temperature and humidity.

Since its value is strongly influenced by quality at the time of sale, it is essential to monitor the alteration of some quality parameters during the storage. This is a fundamental concern for wineries and distributors who should maintain the quality of the wine and prevent the depreciation of its value.

The technologies related to this process are not the latest ones implemented by the company. The company has been using probes within tanks to monitor temperature, pressure and stirring for 25 years. Once they were simple PLCs, difficult to manage and with a manual control, but things have evolved and now the company uses "recipes": for each tank there is some software that allows the operators to set the temperature, aeration, time of shaking. In the last years, this has evolved because nowadays operators have a touch screen version, which is much easier and intuitive. This software provides reports, so if there are problems it's easy to identify the origin and solve them. This is very important for quality purposes. In fact, it is important to make quality wine, but what is even more important is to know how to maintain quality. For example, the bottle of Astoria Prosecco Millesimato Medaglia, that customers buy in January must be the same of the one they buy in September. It's like Coca Cola. A customer can buy Coca Cola, wherever and whenever he wants but each bottle has always the same taste. How do they keep the same taste? They respect standards, just like Astoria does. The company objective is to make everything respecting standards. Anything that can be repeatable and controllable must be done and nowadays this is possible only through software. Software works 24 hours a day, 365 days a year, it does exactly what is required, things that operators can't do.

Sometimes the software implemented by the company is included in the machines, such as in the case of by-pass filter machine. In other cases, the company relies on software houses such as for the probes within the tanks. There are a lot of software houses which provide services and assistance. The company relies on SIEI Automazioni based in Vazzola, a partner for 25 years.

Technologies at the plant level

At the plant level, the main project concerns the substitution of the filling machine because this is the last machine of the line to be obsolete. Currently, the machine is purely mechanical and some processes require the direct control by the operator. Currently the company's purchasing department is evaluating several filling machines. The new models are electro pneumatic machines. They are controlled by a software, in fact for each product there are saved recipes and the operator has to recall them from the touch screen monitor. The skills as well as what the operator is required to do on the new machine is very different. Operators are asked for a qualitative upgrade in order to adapt to the new technologies.

The main problem with the current filling machine is that the company loses from 40 minutes to 1 and a half hours because of the format change. The machine is totally mechanical, so it's necessary to change straws and cochlea to fill bottles of different dimensions. The latest machines on the market make adjustments automatically, by recalling

the correct recipe. Astoria has given its suppliers the size of its bottles and they are developing a universal cochlea with side rails which move automatically positioning themselves according to the size of the bottles. In this way, the format change will require only seven or eight minutes instead of one hour.
There is also a gain in monetary terms, not just in terms of time. In fact, one hour of bottling lost is about 2000€ lost. Furthermore, it's important to consider that the line staff waits for the arrival of the bottles. The company has to pay employees even when they are not working, as they're waiting for the bottles. There are four line operators: one follows the filler, one follows the labeller, one works at the end of the line and one changes filled bottles with empty ones.
Nowadays twelve thousand bottles per hour are produced but they will become fourteen thousand when the filler will be replaced. The new filler will ensure that the operator will take less than ten minutes to change the format in the filling machine, so he will have the opportunity to give support to those who need it. Beyond the extra speed which will shorten the time required for the format change, the advantage will also concern production capacity.
In the last few years, starting from 2014, many machines, which are part of the bottling line, have been replaced: capper, labeller, end-of-line, printers for cardboard. Previously there were purely mechanical machines, but now there are electronic ones with PLC.
The company's labeller is very fascinating because it includes fibres with cameras to control the positioning of labels. The machine rejects the bottles if the label is not applied correctly. The company is now able to guarantee that the label is positioned at the centre of the bottle and its correct orientation considering the glass line. Thanks to these new technologies Astoria is able to guarantee precision to the millimetre.
In the past, the label could be applied above the welding line of the bottle. Thanks to the last labeller which was bought in 2016, the company is able to orient the capsule, so that the label is always applied in the same position. Furthermore, if writing has to appear in the front, this always appears in the front.
Even the mark is no longer placed randomly on the capsule, but it is closed on the back of the bottle. At the end of the entire process, a total control is carried out. This is called "Logilook" and it is a series of cameras that check if everything has been applied correctly. If there is any defect, the bottle is rejected and the operator intervenes to fix the mistakes.

In 2018 the company introduced a vertical warehouse which contains ten million labels. This is an automated warehouse: it's a parallelepiped in which there are fifty- five drawers that contain all the labels. Mr Padovan describes it as a sort of vertical jukebox. Labels are associated with a code. The operator goes into the vertical warehouse with his touch screen, he types the code of the label to recall it and the drawer moves close to the operator automatically. It was a 100,000€ investment that has guaranteed both the order and the precision in the counting of the labels, because there is a person who extracts, downloads and reloads the quantity of the labels. The difference compared to the past is that now the company knows exactly where the labels are, whereas before they were in different places and there were doubts about the accuracy of data.
All of these machines are remote control. In this way, if machines have problems or breakdowns, technicians don't need to come to Astoria to fix them. They can solve problems directly from their offices. This is an advantage because machines can be repaired rapidly and the production process doesn't stop.
Another advantage offered by technology is that each machine has several recipes that are called manually by the operator or by the production order. This system works throughout the reading of the production order bar code.

Technologies in the vineyard

Astoria's vineyards cover 40 hectares. Technologies are implemented also in the vineyards to obtain high quality grapes. In fact, the company has been using four meteorological stations for ten years. They provide information about indicators linked to the agronomic conditions, such as: rainfall, leaf screening, exposure of light, soil data like humidity. These data allow to make decisions in the phytosanitary field to protect plants against fungus.
In addition to this, last year the company joined a project promoted by the Treviso Province Defense Consortium called "BODI". This involves several meteorological stations, which are located throughout the province. Thanks to algorithms, calculations are made to forecast the probability of fungal attacks.
The company uses a drone once a year to make tests, for example for those related to drought problems. The drone allows them to understand which areas need water the

most and to develop maps. The drone flies at 30 meters' height. According to the agronomist Luciano, drones are the technology closest to the earth's surface. It's true that there are also sensors located on quads, but they are more difficult to manage and they are expensive compared to drones. The resolution obtained by satellite is still too extensive for the company extension, as its lands are characterized by a remarkable variability, having hills with various inclinations and various types of soil. For this reason, the satellite with a resolution of ten meters is unsuitable for the company.

The company started to implement technologies in the vineyards 10 years ago. They allow it to be more sustainable and sustainability is very important issue nowadays because of the earth's problems as well as the customer requirements. After their implementation Astoria noticed a reduction in usage. They are used only where and when there is the real need, even from the point of view of the treatments of the plant itself. Thanks to technology, it is possible to understand when the plant does and doesn't need treatment. The company agronomist Luciano affirmed the saving in terms of products consumed, *"Instead of applying 100 to everything, I apply 100 where it is needed, while where there is less need I apply 50 and where there is no need at all I don't apply anything."*

Thanks to these systems treatments have been reduced by 80%.

In the past, agronomists were worried about rain: if they performed a treatment and the day after it was raining, they would have made the treatments again. But today it is not necessary, because new products are more resistant and the company has the chance to verify if the rain has removed them. This was particularly true in 2014, which was a very rainy year. Some of its competitors were always treating, but this was not necessary for Astoria. Savings result not only in economic terms but also in greater environmental sustainability, because less products are absorbed by the soil.

According to the agronomist Luciano, in order to use efficiently the new instruments and the related technologies, technicians, oenologists and agronomists should have a basic knowledge but it's the experience that makes the difference.

They shouldn't rely only on the new techniques, on the contrary they should compare the old-style methods and the new ones. At Astoria when an agronomist starts using these tools and applications, he takes part in training courses provided by those who have supplied the tool. In agronomy there is a strong specialization: there are agronomists who do certain activities and others who do something else, so it is also necessary an exchange of information between professionals.

Virtual reality experience

Another interesting project carried out by the company concerns virtual reality experience. Last harvest was very peculiar. In fact, among the rows of Glera small and powerful cameras for virtual reality were installed. They were cameras with six lenses for 360 ° shots, as it's typical to see on Google Street View, with the difference that the result was not static photos but videos. Thanks to these images, a story was created to show through virtual reality viewers, in which visitors have the sensation of moving among people who are harvesting and among the technicians of the winery, the bottlers, and the oenologist who explain how to taste wine. In this way the company brought the harvest to fairs, meetings, and among its customers all over the world. The shots were also used to create videos for augmented reality: visitors arriving at Refrontolo, looking at certain points in the vineyard or in the barrel cellar, can see the real images overlapped with the integrated images of the harvest or the technicians explaining the various processing steps of the wine. The project has been developed because food and wine tourists are an added value for the company territory, so it wants to make them live an experience as much complete as possible even if they arrive in winter or spring.

Investments and training

Astoria invests approximately 800.000€ per year in technology and innovation. The amount is approximated because it depends from the purchases the company plans to do. For example, in 2019 it has planned investments for 2 million euro because the filling machine has to be substituted. A large amount of resources is linked to storage and production capacity. The filter described above, was replaced by another because of the need to increase production capacity. Purchases are driven both by the increase in the production and the need to replace obsolete machinery. Over years, mechanical components must be replaced because restorations or maintenances make no sense if the machine is obsolete and the cost overlaps its value.

Nowadays everything is run by technology within the company except for the filling machine which will be substituted this year. As far as components substitution, the by-pass

filter machine' s membranes must be changed over time, but the filter structure is guaranteed at least for 20 years by the supplier.
Some investments are made taking advantage from the European and the Regional funds but it depends on the amount of the investment, and they are usually employed for the most expensive purchases. For example, software to monitor tanks costs from 10,000 to 15,000€, whereas a filter costs 250,000€. The company can easily have access to 10,000€ or 15,000€. Furthermore, PSR and OCM should be considered carefully. If the OCM is about laboratory instruments, it can't be used to buy meteorological stations.
Astoria destines resources to train its employees. Training is carried out when an innovation is introduced or when personnel are replaced and it is generally made by supplier's technicians. Employees should know how machines and software work even though they are not required to perform manual activities. This aspect is particularly important because people represent the main obstacle to the development of technologies within the company. The older operators didn't know how to use the new technologies. An operator who has worked on a mechanical machine for thirty years, has difficulties to use a machine which is run by a software.
Difficulties are not met only by employees. Company winemakers who are sixty or eighty years old have difficulties too. But this is not the main problem. The real obstacle is represented by younger generations, which have an open mind but they think worse than their parents. They are presumptuous and they feel as they've already reached the top. They are at the forefront of electronics field, in fact they are the most technological ones in term of mobile phones but they don't want to jump and to adapt to the new technologies. If a 60-year-old operator starts using a new machine, he may have difficulties because he used to work in a totally different way. However, these difficulties may be overcome thanks to training sessions. For this reason, the mental limit is worse, because it is an obstacle that could be easily overcome but there isn't the willingness. According to both Riccardo Polegato and the oenologist Sandrin the old generations are still the best, they still want to learn, to get involved, while the new ones feel at the top. Astoria developed and expanded thanks to the Polegato brothers who have been able to invest and experiment.

Future prospective

As far as the future, the next investments will concern the filling machine. Another interesting project is the new warehouse. The company has recently bought a new plot to build new offices and a new warehouse. Technologies will help in the development of this project. In fact, the land is located two hundred metres far from the current warehouse and the production plant. The project the company is working on, is about a shuttle which will move from the current warehouse to the new one without driver. Without technologies, the land wouldn't be bought. In fact, people would have been employed to move products or it would have been necessary to move the entire production plant. These alternatives would have been too expensive. The project is carried out together with Padua University and a professional studio.

At the moment, the company has a warehouse in Crocetta del Montello, where the headquarters are located, two additional external warehouses and another place which hosts 300 or 400 pallets in the wine cellar in Cravada. In total the company hosts about 3000/4000 pallets, but with the new warehouse the capacity will increase to 5000 pallets. The new warehouse will require a reorganization of the current spaces.

The shuttle will work like automated warehouses where there are robots that follow magnetic lines, like in Amazon. It will have its own reserved path, not accessible to other vehicles, within the company property. It will be a shuttle like the carts that carry bags in airports, the difference is that it will work without driver. It's a small train composed of an engine and eight pallet seats. Probably it will have an incorporated GPS or it will follow magnetic bands, but the project is still being experimented with. The pallet containing bottles must be brought by the operator from the end of the line (where the label has been applied) to the loading roller. Then the shuttle will arrive, it will load pallets and it will take them to the new warehouse, where there will be the operator who will unload the pallets, while the shuttle will come back.

As far as product traceability, the company has not implemented any blockchain technology yet. It has been certified ISO9000 since 1999 and in the last years it has obtained two additional certifications: ISO14001 and SQNPI for the sustainability in the vineyards.

ISO 9000 is defined as a set of international standards on quality management and quality assurance developed to help companies effectively document the quality system elements needed to maintain an efficient quality system. They are not specific to an industry and

they can be applied to organizations of any size. Standards are based on seven quality management principles that managers should apply for organizational improvement. They are: customer focus, leadership, engagement of people, process approach, improvement, evidence-based decision-making and relationship management.
ISO 14001 is a series of environmental management standards developed and published by the International Organization for Standardization. The ISO 14000 standards provide a guideline for organizations that need to improve their environmental management efforts. It focuses on specific approaches such as audits, communications, labelling and life cycle analysis, as well as environmental challenges such as climate change.
SQNPI is a certification which aims to enhance the agricultural production obtained in accordance with the regional specifications of integrated production. It is a certification recognized at Community level (Reg. Ce 1974/2006). Integrated production is defined as the production process that employs techniques and means of production and defence, minimizing the use of chemical products and rationalizing fertilization, in compliance with ecological, economic and toxicological principles.
Traceability is part of the production process by law. The company is planning to introduce the QR code in the bottles, but it hasn't introduced it yet. At the moment, traceability is based on the production batch and the shipping documents that show the batch. The company knowns to whom the batch has gone. In the warehouse there are laser readers, so it's easy to make the association between the loading plan and the bottles picked up by the operator. It is still a manual process because if the company knows that a customer has a certain batch, it has to check manually what that batch actually is. There isn't the identification throughout QR code or other systems yet. Anyway the batch is printed on the bottle, so it's easy to trace the bottle's history.
The Astoria case study teaches us that investing resources in technology and innovation is fundamental because the market is constantly changing as well as the needs of consumers. According to Mr Riccardo Polegato if companies don't invest, they will be torn to pieces by competitors. Furthermore, if a firm is updated, its market value increases overtime. On the contrary, it becomes obsolete and no one wants to pay for an obsolete company.
In Riccardo Polegato's view, technology has also a dark side. Social media, blogs and new digital technologies can be an excellent tool to enhance winery products in the market.

But at the same time, they can be very dangerous. Journalists publish a lot of fake news, manly during the harvest period, damaging companies. For example, in September 2018, different newspapers wrote that Nas Carabinieri seized 7,300 hectolitres of Prosecco wine, 440 of must and two tons of sugar from abroad, together with tartaric acid and sulfuric acid, for a value of about 3 million euro. The same occurred in January 2019, when it was published the news that Nas Carabinieri of Udine province were examining wines obtained with grapes produced far beyond the maximum yield limits and with a natural gradation of the grapes lower than the values established by the relative regulations. Moreover, some types of wines have been qualified with the name of grape varieties different from the one actually employed.
The oenologist Mr Sandrin agrees too. There is nothing abnormal, no scandals. Authorities have to check from time to time. Journalists uses their digital tools to enlarge news and create scandals, but NAS perform their checks very often and nothing is definite until evidences are demonstrated. For this reason, attention should be payed when technologies are used because they have an enormous potential both from a positive and negative side.

Società Agricola Porto Felloni

Agricultural company Porto Felloni has been owned by Salvagnin family since 1975. Nowadays it is run by two brothers: Mr Massimo and Cristiano Salvagnin. When it was acquired it covered 170 hectares, but today it covers 500 hectares. It is located in Lagosanto in the province of Ferrara, not far from the sea, in an area which has been reclaimed recently.

The company cultivates 20 hectares of walnut fruit, 250 hectares of corn between first and second harvest, 100 hectares of peas in the first harvest, 70/80 hectares of green beans in the second harvest and it also produces wheat, tomatoes and soybeans. 90 hectares are cultivated in a way to produce organic products.

The second harvest is a technique which can be applied in very few agribusinesses, first because of the climate and secondly because of irrigation problems. Massimo Salvagnin sows green beans in January and he harvests them in May. After this, corn is sowed where the green beans had been sowed before. This allows the company to increase productivity and to amortize both machinery and soil usage.

The company sells fresh products (tomato, green beans, peas) to processing industries, through producer organizations. It sells corn to dedicated industries whereas wheat is sold to mills. Walnuts have not been produced yet because the company will start to produce them next year. It will sell them with its own brand and the sale will probably be organized through a production chain project which involves four additional companies. In the future the company will probably start to sell its own brand throughout e-commerce channels. It doesn't export abroad, but its customers sell overseas.

All the property is equipped with irrigation instruments. Specifically, with side Pivot irrigation systems and roller systems, which are self-propelled sprinklers. Pivot systems are those in which the movement is based on a central pyramidal tower connected by one or more bays to carriages moved by an electric engine. In these systems the irrigated surface is circular, whereas the water supply and the electrical panels are located in the central tower.

Irrigation is important because without it the company wouldn't be able to produce its crops. There is also a drying and storage plant for cereals and corn with storage of about 130 thousand quintals per year.

There are also panels for the production of photovoltaic electricity. The company has 2.5 megawatts of installed power: 2 megawatts on the ground and 500 on the roof. This is an accessory activity.

Precision Agriculture

The company started to implement agriculture 4.0 techniques because the owners are curious and they believe in the importance of the innovation processes. The owners visited some companies in the USA in 1997 and they noticed that technologies were implemented easily so they tried to bring home as much as they could. They asked contractors to create maps of force. This is the initial step to take on and contractors are a good solution if the company has a limited budget because it hasn't to buy anything, it has just to pay contractors for the service they provide and the cost is lower.

In the first years the owners tried to understand how their soils behaved in terms of yield. The company soil is naturally uneven, because a great variability can be found. In fact, there are sandy areas as well as clay and loam. For this reason, precision farming helps. Variability can't be changed or improved, but it can be managed through the most suitable techniques. In order to better understand soils, the owners performed georeferred physical chemical analysis. Georeferred means that some points have been identified and these points are used to collect soil samples. They have been identified through a GPS system implemented in a quad. The results obtained have been sent to a laboratory to make the chemical and physical analysis. The analysis has been used to realize maps of force which have provided useful information about soil characteristics.

In 2012 the company implemented solutions such as soil surveying through electrical conductivity. This is called an ARP system. It was the first company to introduce this system in Italy. This experience has provided it with very useful results. There are very few companies in Italy which provide this service. They cross fields with their equipment to inject electricity inside the soil. Data is then read at three depths. Through the passage of electricity, a sandy soil is resistive whereas a clayey one is conductive. Thanks to a dedicated algorithm it is possible to understand the texture of the soils. It is a sort of map of force, even if it doesn't use chlorophyll but energy. A clay soil allows electricity to pass, a sandy soil does not. This analysis is then correlated to chemical-physical investigations and the exact maps of the soils are created. The maps are turned into cartographic models, and consequently, the prescription maps are created. The key point is to have software which translates soil maps into prescription maps. The company has one created by Technofarming which is both management and cartographic. Before of the ARP system implementation, the chemical-physical analysis of the soil was done with samples taken each hectare and a half of land, while with the ARP system, data cover the whole land, point by point at three depths: at 50, 100 and 200 cm. In this way Porto Felloni understood where the soil problems exactly were.

As underlined before, software packages are very important in the management of land. The company is equipped with software for the management of company data, at the management and cartographic level. The various software packages are complementary and talk to each other. For example, tractors have sensors and monitors to collect data from the soil, data is downloaded by default through the monitors and it is sent directly to the offices. There is a direct transfer from the countryside to the offices without the need of any USB key. This allows the company to control and trace everything which is carried out in the fields. Some software programs employed by the company are: Topol and JD Office.

All the agricultural companies which supply their products to third parties have to fulfil a Treatments Register or Rural Notebook. In the case of the company, it is connected to the warehouse through software. In fact, once an operator completes it, the automatic unloading of the warehouse of the products such as fertilizers, pesticides and all the other products that are used will begin. In this way the warehouse is always up-to-date and it must be by law because the warehouse is subject to controls. In 2018 the company warehouse was checked by the forest police and the ASL.

Electronics increases the safety, effectiveness, precision and efficiency of agricultural equipment. Anyway in the past, every manufacturer used their own proprietary solutions, which required special adaption for every combination of tractor and implements. ISOBUS is the term commonly used with reference to ISO11783: 'tractors and machines for agriculture and deforestation: serial network to manage control and communication'

All these tools help the company to understand how to manage cultures and prevent any stress. They have changed the modus operandi of both agricultural entrepreneurs and operators. Nowadays, there are reliable instruments that provide useful information so that they don't have to look at the sky, or to look at the calendar before performing treatments. Less operators are required to do a larger job and these technologies save time, which can be dedicated to other activities. The company has also increased the variability of its crops, in fact next year it will expand its production and it will start to produce walnut fruit.

In addition, the company has experienced an increase in productivity, both in terms of quantity and quality. All the products are measured in terms of standards, from tomatoes to corn. There are pre-established parameters that define the quality of products. A tomato obtained through precision farming techniques has a better quality because if there is an area of the field that has problems, the operator can identify it immediately and solve them. Mr Salvagnin explained that if there is an area which is characterized by ripening problems, he will use natural products to grow that specific area of the field. In this way he avoids overripe red tomatoes in other areas. All the agricultural entrepreneurs pay particular attention to quality because it has an important value.

Contrary to expectations, Mr Salvagnin affirmed that the income is much more based on quality than on quantity. A quintal of tomatoes can cost between € 9.50 and € 7. The price difference is dictated by quality. The tomato quality is measured in terms of:

- Degree brix: which is linked to the sugar content;
- Breakages;
- Colour

As far as peas, quality is measured in terms of purity level. According to Mr Salvagnin, if the land is not homogeneous, there could be areas in which peas are very hard and consequently their price will be low. In fact, for peas the tenderometric degree should be low. A tenderometro is the tool employed to measure the hardness of peas and therefore their degree of ripeness. Specifically, the tenderometric degree measures the resistance of the seed to be perforated by a tip. It is the pressure necessary to crush 1 dm3 of seed.

Green beans are classified into four categories: A, B, C, D and there are parameters that distinguish them. The higher the quality, the higher the price.

Corn too is evaluated in terms of quality. The major problems related to corn are linked to drought and aflatoxins. The latter are toxic substances produced by the secondary metabolism of some ascomycete fungi called Aspergillus Flavus and Aspergillus Parasiticus. These organisms develop on many plant substrates such as cereals (especially corn), oil seeds, spices, grains and dried fruit, both during cultivation and during their storage. Aflatoxins problems especially occur when the land collapses and the operator doesn't realise this. If the aflatoxins degree is high, green beans can't be used for feeding. Anyway if they have been managed with appropriate techniques, the aflatoxins degree is low and they are of higher quality.

Agriculture 4.0 also allows for savings in the use of machinery. Thanks to self-driving tractors and machines, movements within the field has been greatly reduced by 10%/15%. Consequently, fuel consumption has been reduced, as well as machine consumption and staff hours by 10%/15%. Soils aren't stepped on, so they are not damaged by the passage of machines. There is a saving also in terms of products, because where fields are not performing as well, less seeds and fertilizers are distributed.

Investments and the future

As far as the future, the company is working on some projects with Padua University and a foreign professional study to manage soil moisture with other systems to avoid probes, but these project are still in the development phase and the technologies as well as the software that will be employed are not known so far.

The company collaborates with Padua University and Professor Basso who works in the Michigan University. He is a friend of Mr Salvagnin and he is one of the premier experts in the field of precision agriculture. The company's owners met him when he started working with precision farming techniques and he always gave the company's owners incentives and motivation to discover and implement innovative methods.

The company doesn't invest a huge percentage of its turnover in technology and innovation. According to Mr Salvagnin, it is possible to buy a machine equipped with variable rates technology by adding from 10% to 15% of its value. For example, a tractor costs 150.000€, if it has a monitor and an antenna for precision agriculture, these instruments costs from 10.000€ to 12.000€, which is a low percentage compared to the whole cost of the tractor. All farms and agricultural companies take advantage from rural development programs, provided by the European Union. These plans allow them to save 35/40% of the cost. Agricultural company Porto Felloni takes advantage mainly from production chain plans rather than rural development programs (RDP).

The main difference is that production chain plans require companies to be involved in all the phases, from sowing to marketing.

The Rural Development Program (RDP) establishes strategies and interventions for the agricultural, agri-food and forestry sectors to develop rural areas. Each RDP develops over a period of 7 years. The RDP is addressed to single companies which adhere to a rural development plan where a series of investments are planned. There is a call and investments are evaluated: they could be in the ranking or not. In the first assignment, young farmers under the age of 40, usually receive a higher score because it is a first assignment. In fact, the European Union wants to provide greater opportunities to young people to buy machines, irrigation systems or to finance building renovations.

Difficulties in technology adoption

At first the company experienced a lot of difficulties, but it was able to manage and solve them. First of all, there was a lack of experience. The owners saw those advanced techniques in the United States, where cultivations as well as territory and climate were completely different. So, before implementing the new technologies they had to observe and study the Italian soil in order to know as much as possible about their land.

Secondly, the company adapted the machines because they came from the USA and they were suitable for the American soils not the Italian ones which are smaller and uneven. The American machines were extremely large and they were equipped with many tools, even those that were useless in Italy. Today it's possible to buy a tractor and adding instruments over time.

In Mr Salvagnin's opinion, the most important thing is to understand the soil. The cheapest step to do at the beginning is asking contractors for maps of force. Thanks to them, farmers understand the soil and then they can invest in the purchase of machines. It's useless to buy machines if you do not know what to do with them.

To sum up, the main difficulties were related to the adaptability of the machines and the use of software. Anyway, the company also faced economic difficulties and the fact that not all the personnel were prepared to handle certain machines. In order to overcome this problem, the owners invested in training sessions. For example, this year the company has taken part to a 40-hour course together with nearby companies so that the personnel are trained in the use of these solutions. It was organized and financed by OMPRA which is a Confagricoltura training institution.

The day before the interview, Mr Salvagnin held a meeting with a group of three hundred older farmers who, he reported, looked stunned by this training session. He knows that markets are penalizing farmers because prices are always lower. The price of corn is more or less like ten years ago. Farmers can't compete on price, they have just to make more quintals and more quality products. Farmers should also join together.

For these reasons, it' s essential to invest in technology and innovation. Mr Salvagnin affirmed that new solutions should be found to increase profitability. Contractors help if the farmer is not able to invest on his own. It's important to involve many actors, from companies to contractors, from machinery's suppliers to farmers who employ them. According to him, a change of mentality is definitely needed. What is missing today is the link between agronomy and cartographic solutions. In fact, it's easy to find agronomists who don't want to dialogue with new solutions even if there would be the need.

Latteria di Soligo

The company was founded in 1883 and it's one of the first cooperative companies in Italy. Nowadays, Latteria di Soligo is one of the leading companies in the Treviso area. It produces fresh milk and cheese, vegetables, fresh cream, butter, eggs, ricotta and parmesan, yoghurt, caciotta and mozzarella fior di latte. The specialties are Stracchino, Casatella and Trevigiana DOP.

It is inspired to the social thought of the Church developed by professor Giuseppe Toniolo who was professor of political economy and sociology at the University of Pisa. He was born in Treviso in 1835 and he developed a theory about the commitment of Catholics in politics as pope Pio IX issued the "Non éxpedit" in 1874. Because of this act, Catholics couldn't take part to the politic life. Professor Toniolo affirmed that it was right to do business and companies must enhance people. He elaborated his theory taking into consideration the corporations in the city of Florence during the Middle Ages. Toniolo married a women belonging to Schiratti family, and thanks to this marriage and his knowledge he managed to collect around him one hundred farmers in the area of Soligo and he transformed them into entrepreneurs. He explained them that instead of bringing milk or selling it to the sharecroppers, they had to put together enhancing their entrepreneurial activity, producing cheese and milk.

The dairy was born as a challenge against the status quo, it was a revolution at that time but it has continued to be innovative over time, in terms of processes and products. The last phase the company is facing now, involves the innovation of the cooperation governance model.

The company charter which defines its mission was written at the end of the 19th century and it is still effective nowadays. The purpose of the dairy, therefore the company's mission, is divided into five main points:

1. collecting milk from the members and paying a fair price;
2. turning milk into perfect products. The charter doesn't talk about quality. It is written about perfect products, which are the ones without defects;
3. creating a large-scale trade;
4. helping farmers to continuously improve their livestock and breeding techniques;
5. the last point concerns the management and the division of profits.

Today the company has 130 employees, 70 sellers and 7 distribution platforms. It sells all its products to retailers. In particular, Gdo and Ho.re.ca are the main markets. It has three production plants. One is dedicated to the milk. It is located in Caposile where fresh milk, long-life milk, fresh and non-dairy creams and some desserts are produced. The second plant is located in Soligo. Fresh soft cheeses, including mozzarella, are produced there. Finally, in the Braganza dairy, which was incorporated in 2003, Grana and Asiago DOP cheeses are produced.
Thanks to a widespread sales network in the Northeast, it has strengthened its presence also in the North-West and in the Center, thanks to investments in fresh logistics. It works 700,000 quintals of milk every year. It is produced by 200 member companies, located between Veneto and Friuli Venezia Giulia. The turnover is around 73/74 million euro and it has been increasing compared to the previous years.

	2011	2012	2013	2014	2017	Var %
Turnover Million €	€61.896	€ 62.602	€ 65.003	€69.299	€71.828	16%

The company exports are very limited. It has an export manager, but export is around 1%. In Europe it exports to Slovenia, Croatia, Austria, Germany, France, England and Spain. The company is currently working on a project to export to China and Unites States. According to Mario Dalla Riva, who is Latteria di Soligo marketing manager, the main problem is that the property is in the hands of farmers who are extremely cautious. Regulatory difficulties are not a problem as they can be overcome, the fundamental thing is to have products that people like.

Technology and innovation within the company

The first innovation carried out by the company was linked to the ability to produce a hygienic milk. In the ‘60s the company equipped with a pasteurizer that was a novelty at that time. It takes contaminated milk and it sanitizes it through a heat treatment.
In the '70s a product innovation was introduced as the company started to produce mozzarella. Until that time, people in the north didn’t know what mozzarella was. Neapolitan immigrants arrived in Treviso and Conegliano. They were pizza makers and they needed mozzarella. They asked Latteria di Soligo some milk. But it was quite demanding to pro-

duce mozzarella so they asked the dairy's director to produce mozzarella directly. Neapolitans though how to produce it and this was an innovation carried out without market studies.

In the '90s the innovation activities were linked to the use of single-component packaging material, which was plastic. In the past, more components were employed: paper, cardboard and plastic. The company chose to use only plastic, in order to encourage the reduction in the production of packaging materials that become waste. The next challenge will be to use materials which are recyclable, recoverable or biodegradable because from 2025 there will be a European legislation aimed at reducing plastic. The problem is to find the alternative to the packaging materials that guarantees the hygiene of the products.

In 2001 the company introduced the online supply chain traceability. It needed to demonstrate the origin of its products: it offers excellent milk but it also offers its consumers the opportunity to see where it is produced. It has obtained the first certification through a third party called CSQI and it adopted the Quality Verified brand line. It is defined by the Regional Law 12, issued in 2001. It involves companies from many different sectors (fruit and vegetables, meat, dairy and fish) and it guarantees "Made in Veneto" agri-food firms to present itself to national and international consumers making them sure that quality standards are respected. For what milk is concerned, QV brand is based on three main pillars:

1) Control of the entire production process, from breeding to packaging through the certification of independent entities;

2) Particular nutritional properties of milk, thanks to the use of food rich in "Omega-3" polyunsaturated fats, which act positively on the cardio-vascular system;

3) Attention to animal welfare, through suitable housing conditions.

As far as the second pillar, the company worked on a special project. developed together with Professor Bailoni of Padua University in 2008. The aim of the project was to demonstrate that feeding cows with natural food such as flax seed can contribute to improving the Omega 3 value of the milk produced. The project was linked to the Measure 124 of the rural development program 2007/2013 *"Integrated Supply Chain Projects - Cooperation for the development of new products, processes and technologies in the agricultural, food and forestry industries".*

According to Mr Dalla Riva this was an innovation too because the acidic profile of the products was modified through the feeding of the cows. The milk fat composition is different from that of the other producers. In fact, the company farmers give cows at least 250 g of flax every day, which is a source of unsaturated omega-3 fat acids.
In 2016 the company introduced the Safetypack system because there was the need to be sure that oxygen and other gases couldn't enter in the packages containing mozzarella. In food packaging industry the use of gases other than air in the process of manufacturing and sealing of food items to the consumer chain (supermarkets and retail points) has progressively grown. It follows that the precise measurement and control of the atmosphere within packages represent a requirement in the food and packaging industries.
Safetypack is the technology that has made Latteria di Soligo the first dairy industry in the world to guarantee 100% the safety of the STG Mozzarella, passing from a sample quality control to the infrared one on all packs. In fact, in the past controls were carried out manually, packages were brought to the laboratory for analysis. Controls were performed on a sample basis: in order to check the oxygen level, the package was punctured and consequently it had to be replaced.
Safetypack is a technology which allows the monitoring and measuring of the level of gas inside the sealed food packages in a modified atmosphere. The machine has been produced with the Safetypack EU project and it has been developed by L pro and FT System. The former company is located in Padua, whereas the latter in Piacenza. It was installed and validated by the Danish Technological Institute which is a self-owned and not-for-profit institution. Using a laser spectroscopic sensor, it is possible to check the internal protective atmosphere and the integrity of the packages of the entire production line. For example, it is possible to measure the oxygen level contained in the packaging: each package should contain not more than 5% of oxygen. Specifically, it works as follows: packages come to the production line; they enter the machine where two belts make them move in front of the laser which measures the oxygen percentage inside the package. The light gets through the container, it interferes with the oxygen molecules inside, and it allows a detection of the oxygen present inside in a non-destructive way, without any contact. To distinguish one gas from the other, the machine illuminates it with a laser light at one wavelength at which only that gas absorbs light. By measuring the absorption of light, it is possible to know the concentration and also the pressure of that gas inside an ordinary

packaging. This prototype can be used with any non-metallic packages and it can operate both on (partially) transparent (food trays and bags, bottles) as well in almost non-transparent containers.

The laser sensor does not damage the packaging and it keeps the food unaltered, allowing the controls to each product, before it leaves the dairy. The machine is also equipped with a monitor where operators can examine the results of the detection. The main advantage provided by this technology is linked to the fact that the organization can correct in real time those packages which are not compliant before products are damaged. In this way the company ensures that products maintain their freshness, taste, scent and their organoleptic properties. Thanks to this new technology the company is able to guarantee an optimal product without using preservatives. According to the president Mr Lorenzo Brugnaro, the company is giving certainty to the consumer, because it's the packaging which protects food, as the air damages it.

Latteria di Soligo is currently working on a project aimed at developing new dairy products employing the components of whey together with Agricansiglio, Latteria Sant'Andrea and the University of Padua. It is called "Innovawheyfood" and it is part of the European project to increase the innovation activity of firms. It employs new technologies, such as the mid-infrared spectroscopy (MIR) for the analysis of specificity. Spectroscopy is the experimental procedure by which the frequencies of the radiation absorbed or emitted by particular substances are measured. Particularly, this technology allows to better use the whey. Actually whey is considered and treated as a processing waste, but the aim of the project is to take some of its components and transforming them into new products. This will guarantee a benefit for the territory and for the industry in general.

Advantages and difficulties related to technology implementation

All these techniques bring to mind the company mission of producing perfect products and they demonstrate its interest towards consumers and their healthy and genuine nutrition. As far as perfect products are concerned, technologies improve the ability of the firm to produce them.

Before investing in innovation it's important investing on people, because innovation come from them. In Mr Dalla Riva's opinion, staff training is necessary. The first department of the dairy is the barn and for this reason, the firm is recognized as a producer

organization, according to the European regulation. Its members are committed to give 100% of their products. This explains why the company dedicates time and resources to the training of both farmers and employees.
Research is continuously carried out by the firm. In fact, it collaborates with the best universities and researchers on animal well-being projects, as well as on assembly line production in factories. It knows well the treatment of whey which is a by-product of milk, as well as the best techniques to feed the cattle.
Innovation within the company is also encouraged by the Italian Constitution as it stimulates and encourages cooperative enterprise model in the article 59.

"La Repubblica riconosce la funzione sociale della cooperazione a carattere di mutualità e senza fini di speculazione privata. La legge ne promuove e favorisce l'incremento con i mezzi più idonei e ne assicura, con gli opportuni controlli, il carattere e le finalità"

Italy recognizes cooperative enterprises because they have a social function. In addition, in the agricultural world, taxation for cooperatives is lower compared to other sectors.
Furthermore, the company can take advantage of the facilities provided by the European Union through the rural development programs, because it produces food. Thanks to these programs, the company has the chance to participate in development, training, research and innovation projects.
At the moment the company is intensifying research and innovation. With reference to the last century, the commitment to innovation is more intense nowadays. Workers and farmers live this innovation and they are involved in the process. The organization adapts, learns and improves professional skills because innovation brings innovation.
Mr Dalla Riva explained that the company has been working on how to use whey by-product for ten years. This is an issue unknown to Italian people, while it is well known in the northern Europe because the north has always believed and invested resources in the milk supply chain.
According to Mr Dalla Riva, technology helps to increase productivity but something internally should be changed to further increase beyond technological investments. In fact, Italy used a system which brought about damages to farmers and dairies. In 1984 prices of raw materials started to be controlled and milk quota system came into force. Within

the European Community many tons of milk, powder milk and butter have been produced since the late '70s, exceeding the market demand. According to the documents written by the European Commission, the surplus reached one million. As a consequence, the income of the farmers, who enjoyed European subsidies to enhance exports, was thinning. For this reason, the States of the European Community agreed to self-limit their production. In order to decide how much each country could produce, the production of the previous year was considered, (1983), and the amount was then divided by the producers, assigning each one a share. Those who had exceeded that limit would have to pay a very disadvantageous tax. Differently from other countries, Italy produced less of its own national need in those years. In addition, farms were smaller than micro-enterprises and data collection and monitoring would need a dedicated administration that did not exist. The initial limit established for Italy by the minister Filippo Maria Pandolfi was nine million hectolitres. This system was abolished in 2015, but Italy overtook milk quotas uninterruptedly from 1995 until 2009. As a consequence, the European Court of Justice has defined Italy as defaulting because the Italian authorities have not taken the appropriate measures to recover what individual producers and dairies had to pay for the production excess. The Court has specified that Italy's failure was not the failure to recover money, but because it didn't arrange the appropriate legislative and administrative means to ensure the regular recovery of the additional levy from producers. Italy will therefore have to comply with the indications of the Court. In case of non-compliance, the country could be obliged to pay penalties.

Mr Dalla Riva thinks that time is ripe because things are changing. Italy is part of Europe and the latter is one of the main producer of milk worldwide, after New Zealand and United States. The European Union is launching new economic policies aimed at promoting European products all over the world and the company is taking advantage from them. As far as exports are concerned, new technologies are also perceived by Latteria di Soligo as a tool to expand products in new countries.

The next step will be to activate collaborations with other companies and cooperatives. Creating synergy on common issues is useful to reduce costs and to increase the profitability of research. Nowadays the network is not just made by the internet, it is also a network of relationships between operators, entrepreneurs and workers and therefore it is right to collaborate. Mr Dalla Riva affirmed that companies can't grow and succeed on their own, especially in the dairy sector.

One of the main difficulties faced by the firm is the relationship with other companies and operators. Mr Dalla Riva suggests to read the writings of the cooperative's founding fathers to find new ideas and new incentives to dialogue with each other.

Another difficulty was the fact that the company operates in a market that is global, so it's fundamental to make consumers understand that products are of excellent taste and of superior quality. Communication plays an important role here. Anyway the company has not enough resources to promote products on TV or radio spots. The company takes part to local food and wine events, but also to cultural, sportive and social ones. In this way it creates a positive company image in the eyes of consumers. It also supports initiatives such as the Alice Operation: when consumer buy Latteria di Soligo products, an amount of the proceeds is destined to support the anti-violence centers for women.

Even if there is internet that encourages virtual but not real socialization, the company prefers promoting real socialization processes, it wants to be recognized as the company which can help people who are in troubles other than offer excellent and fresh products.

Suggestions for the future

There are some businesses, mainly the smallest ones, that refuse to innovate, like those who choose not to use the mobile phone. However, in order to be competitive and grow, it is necessary to adapt but not to copy what others do, being brave enough to show their own values.

The company's farmers have always believed and trusted the organization and in this way it was able to survive two world wars. There are few companies which was born at the end of the 19th century, which are still able to survive. These firms are those that have been able to continuously renew themselves.

To those dairies which have not invested resources in technology and innovation yet, Mr Dalla Riva suggests to hasten to catch up with the other companies because the market is rapidly changing as well as customer needs and tastes. Modern technologies help to reach these new needs. For example, over the years the consumption of meals outside home has increased. Moreover, time destined to cook food has decreased. As a result, the space for pre-packaged foods has quadrupled in stores and the number of mono-product packages has increased. Consumption has changed. So companies have to develop ready meals to respond to the market demand. The new challenge the company is trying to face is this and therefore in the next future, investments and attention will be paid to these issues. Actually the board has not taken a decision yet, but the market is asking for this and the company will probably satisfy it. This would mean starting to produce products like: frozen Tiramisù, frozen pizza, pie with Casatella Trevigiana. According to Mr Dalla Riva, tradition won't be lost. In fact:

"It's good to preserve tradition, but it is a fire that must be cultivated and ash shouldn't be kept."

Stefano Zamagni, Italian Economics professor

Another fact that demonstrates consumers have changed their behaviour is the increasingly attention paid to the product label. Customers look for products without preservatives or other chemical substances. Nanotechnologies and sensors can help companies like Latteria di Soligo in achieving this objective.

The key for succeeding in the future is to combine tradition, and innovation and technology could be a means to enhance this combination.

Oleificio Zucchi S.p.A.

Oleificio Zucchi is an unlisted joint stock company. It has its headquarters and its production plant in Cremona. It was founded in 1810 and it has always been a family owned company, in fact the Zucchi family started to produce oil in 1810.
According to historical documents, the family operated in the oil sector as artisans. In the autumn of 1893 Vitale and Vincenzo Zucchi moved to Pizzighettone as renters of a mill for grinding cereals. Their activity was transformed into industrial production because of the volumes produced. In the 1920s, the first industrial plant was built near Cremona under the leadership of Vitale Zucchi. The plant became a real factory in just sixteen years. In those years the refining process was introduced allowing the sale of Zucchi oil on the mass-market. 1946 is the official birthdate of the current Oleificio Zucchi S.p.A., when the firm was registered in the company registration list.
In 1955, Standa (which was an Italian chain of department stores) proposed the company to pack the oil in glass bottles, creating a real brand called Zeta. After that an innovative continuous cycle refining system was built, because there was the need to produce large quantities of oil ensuring its quality.
In the following decade the historic Zeta brand passed from the processing industry to retail. In the early '90s, there was the need to move the plant to its current location in Cremona near the waterway, in an area of 80,000 square meters.
Under the leadership of President Vito Zucchi, the company has further developed in terms of turnover and this led, in the mid-1990s, to the last significant structural expansion of the packaging department. As a consequence, the production capacity has increased.
Giovanni and Alessia Zucchi, Vito Zucchi's children have entered the company recently. The decision has been made to alternate the management of the firm between Alessia and Giovanni for a five year-period (the company is currently run by Ms Alessia Zucchi).
Oleificio Zucchi S.p.A. operates both as a Consumer Division producing olive and seed oils with its own brand and private label and as a Bulk Division producing bulk oils for the food industry. It doesn't sell only in Italy, as it exports to forty-seven countries around the world. Its customers are distribution companies, players like Ho.re.ca. and Food Service and food industries.

The turnover in 2017 was around 201 million. It has been increasing since 2014 and it was 6% higher than the previous year.

	2014	2015	2016	2017	Var %
Turnover Million €	€156.076	€167.251	€188.239	€200.622	128,5%

52% of the turnover is related to the consumer division while 48% to the bulk area. The company employs 139 people.

The current industrial plant covers 110,000 square meters and it is characterized by a production capacity of about 500 tons / day of refined oil and 1,500,000 litres / day of packaged oil. The activity takes place entirely within the Cremona plant.

The company doesn't squeeze olives, it just buys oil and it transforms it into a blend. Its production process can be summarized into four macro phases:

- *Procurement*: the rough oil is purchased from national and international suppliers. The main supply markets are: Senegal and Brazil for peanut oil; Ukraine and Russia for sunflower oil; Italy and France for corn oil; Italy and Brazil for soybean oil; Italy, Spain and Greece for olive oil.

- *Refining*: the refining process consists of six distinct phases:

1. Degumming: impurities, humidity, residual flours, lecithin are eliminated through decanting and centrifugation and the mucilage that is detached is eliminated thanks to a special centrifugal separator.
2. Neutralization: organic and mineral acidity is removed.
3. Winterization: the oil is cooled to about 8°-10 ° and the crystals of solid triglycerides and the waxes are separated through a further centrifugation.
4. Discoloration: a large part of the colour of the oil is removed, leaving it straw-yellow;
5. Deodorizing: to eliminate unpleasant tastes and smells.
6. Polishing: a further filtration is carried out to eliminate all the unnecessary substances and to obtain a clear and bright appearance.

The output oil is blown with nitrogen to protect it from oxidation and it is stored in special stainless steel silos placed inside a structure at a constant temperature of 16 °. At this point, the bulk product is sent by tanker to the food industry, the consumer division product is sent to the packaging department.

- *Packaging*: the department is built according to the most modern and automated production logic.

- *Marketing*

The main governing boards of the company are the shareholders' meeting, the board of directors, the board of auditors, and the supervisory body. The shareholders' meeting is composed by the two owner families, Zucchi family (which has the majority of shares) and Della Torre one.

The company owns holdings in two related companies:

- Nuova Odo S.p.A., which is specialized in the production of margarines and semi-finished products for the confectionery industry;
- Olearia del Garda S.p.A., which produces extra-virgin olive DOP oil.

The board of directors draws up the guidelines for the strategic management of the company. It is composed by three representatives of the Zucchi family, one representative of the minority and two councillors. It’s the top management which deals with issues related to economics, environment and social issues.

The company's vision is to be recognized as "The Italian oil company", bringing to customer tables a quality, traced and sustainable oil.

With reference to the sustainability policies implemented by the organization, the main objective is to carry out production activities in a way to reduce pollution and to use resources efficiently and effectively. Operatively speaking, the company has adopted the SA8000 certification and as a consequence a Social Performance Team was established. The SA8000 certification is an auditable certification standard that encourages organizations to develop, maintain and apply socially acceptable practices in the workplace. The SPT is made up as follows: the General Manager, the Human Resources manager, the Health and Safety manager, the Bulk Operational Processes manager, the packaging department manager, a non-managerial employee, all the joint trade union representations. Among these there are also workers. This composition, based on a company choice, exceeds the SA8000 requirements, which would include only four components. The meetings are held monthly: also in this case the company has chosen to go beyond the requirements of the standard, which would require just two meetings per year.

“Filiera 4.0” project

In order to offer the best, Oleificio Zucchi has always invested in technology. The plant, enjoying a modern design, allows for the latest technical plant engineering innovations to respond to the market needs in terms of product quality and environmental impact. This is confirmed by continuous technological investments and the adoption of environmental and quality certifications.
The company has focused on the traceability of the supply chain and it has brought to the market the first certified extra virgin olive oil that has been completely tracked thanks to a project called "Filiera 4.0". Starting from 2015, the project has allowed the collection of a large amount of data coming from all the players in the supply chain. But it was not enough to have "lot of data", the project wanted to achieve real traceability of the product and it wanted to have tools to evaluate and certify sustainability and quality. To respond to these purposes, it was necessary to collect data related to all stages of the supply chain from the cultivation of olives to their harvest, but also data about pressing, milling, bottling, transport.
The project was born in 2015 from an idea of the president Giovanni Zucchi, who is now vice president. In 2015 the project started to be developed by collecting all the sensitive data related to traceability, both for olive oil mills and farms. A portal, which is the 4.0 Portal, was created to include all the data. Specifically, with reference to farms, data is linked to quantity, type (cultivar), oil yield, cadastral parcel sheet, address (where they are located) and all data concerning the Rural Notebook. As far as olive oil mills, it’s important to know that olives are produced by farms, they are harvested by farmers and they are brought to the olive oil mill. The crusher sinks them. At a bureaucratic level, all these movements, from what exits the farm to what enters the crusher, must be registered and there is a portal called SIAN which is managed by the ministry, which tracks all these actions.
As far as the first part, the company decided to take all this information and transfer it to a dedicated portal which is a 4.0 Portal. When the oil arrives at the production plant, it is possible to trace it and tell consumers, how much of that oil comes from the province of Bari rather than from that of Naples. In fact, the majority of the company suppliers are located in southern of Italy: Lazio, Puglia, Molise, Calabria and Sicily.

The company is able to give consumers a series of information, even though it collects much more data. Information is separated by type, that which concerns farmers separated from that which concerns olive oil mills. In 2015 the company communicated the region of origin for first. Since the beginning of 2017, it is communicating the province of origin and the cultivar (i.e. the variety, which olives are part of that oil).

Data was inserted manually by employees, because information needed to be verified and checked. The employees moved data, which was contained in paper sheets, to the electronic world. Currently, also the new suppliers are still inserted manually because controlling data is a very important part of the process. In fact, the company has decided to provide customers additional information about the products they buy, but this data must be precise and correct. Anyway, the company tries to gain suppliers loyalty so, after having entered and checked data the first year, the second year data is just controlled and updated. The update requires less time than the insertion process.

To access the information made available by the company, costumers have to access 4.0 Portal on the web. Every Zucchi oil bottle contains a batch number and a verification code which must be typed in the portal. Costumers have to visit the website www.zucchi.com. At the top of the home page there is the "Traceability and Sustainability" section. By clicking there, it is possible to accede two categories:

- Discover the product
- Traceability

After having chosen the option "Traceability", the customer has to select his type of oil, olive or seed, and he has to insert the batch number and the product code which can be find in the bottle.

As far as the traced oil, information given will be about the origin (country, region and province from which the oils come from) and a description of the cultivars that make up the blend of the bottle purchased. Depending on the product, it is possible to know additional information other than the origin. For example, if the customer has purchased a sustainable oil, he will be provided with additional information related to sustainability, biodiversity and other parameters. He can also download an analysis certificate of the purchased batch.

Information can be accessed directly through the bottle. In fact, there is a printed QR code in the bottle label.
This is a service for both Italian and foreign consumers, so the website is available in English and in Italian. Labels are also different because they have different characteristics depending on the country to which they are destined.

Advantages linked to online traceability

According to Elisa Novelli (who is an Oleificio Zucchi's agronomist), the advantage provided by this system is that the company knows the supply chain in detail and it is also a way to make it more responsible and sustainable. From the food industry point of view, this project allows to provide customers with products which are controlled, from the collection to the bottling and this is a guarantee for the consumer.
Furthermore, the system provides also advantages in terms of the company's reputation. From the company management point of view, the project has allowed a reduction in terms of time and costs. All the information related to oils before it enters the company is managed throughout the Portal 4.0. All the data related to the internal procedures is managed by another software.
It is possible to describe the entire system as follows: everything that concerns primary production is managed by the portal where all the information about crushers, suppliers and farms is included. When the raw materials enter the company to be blended, software manages all the internal processes and information. The portal and the software are interconnected and they communicate between each other through a SAP developed by BMS company. It stands for Systems Applications and Products in Data Processing. It is the ERP (Enterprise Resource Planning) system that aims to integrate all the different modules the company has implemented. Thanks to this interconnected system, mistakes and the slow transfer of information have been reduced because all data merges into a single point from which it can be easily found. In addition, this system has been demonstrated to improve the productivity of the company, to lower costs and to help in making strategic decisions. With the SAP implementation, in addition to obtaining a certain and univocal data, Oleificio Zucchi has drastically improved the timing of analysis and this has allowed to better attack the market and to review or confirm strategies in real time. The

speed and efficiency of reporting has increased by 30% and this has made the company even more competitive.

The quality too has improved. The quality of the oil depends on several aspects: the variety of olives, the production area, the climate, the characteristics of the soil, the ripening of the fruit at the moment of harvest, the method through which olives are stored, the time period between the olive harvest and the milling, the type of extraction. The company guarantees the quality of its products through the supplier selection. It selects them in an obsessive way: farmers but especially crushers because the latter are the riskiest ring of the chain. As far as Italian suppliers, the company has looked crushers that had the ISO22005 certification, which is the one that deals with traceability of the supply chain. The same thing it tried to do abroad. In 2016 all the foreign suppliers who were not ISO22005 certified (this is not a fundamental requirement abroad), were certified by an Italian third party. The fact that data is all collected in the portal, helps the company to control its suppliers and to verify the respect of the quality standards.

When selecting suppliers, the company takes into consideration three main aspects:

1) Economic factor: the supplier's ability to make profits
2) Environmental factor: the supplier's ability to produce quality products limiting the environmental impact
3) Social factor: the supplier's ability to guarantee human rights, fair operating practices, consumer protection, community involvement and development.

   At least once a year, generally in the month of February, when previous year data is available, the evaluation of the various suppliers is carried out according to the methods and criteria previously described.

Another way to ensure quality is the use of the right instruments. For example, if it stored in ideal conditions, oil can be more stable and it can preserve its chemical and organoleptic characteristics longer. The main enemies of oil are temperature, light and oxygen. The company oil is stored in stainless steel silos which are kept at a constant temperature of 16 degrees.

Difficulties in project development

According to Ms Novelli, the main difficulty in the project development has been people. Compared to other sectors such as the wine, the oil sector is characterized by people who

are older, therefore they don't know technology and it is not possible to teach them or to make them understand the advantages provided by it.
The project was born by asking farmers and people who worked with crushers to enter information into the portal. The company also recognized an economic reward for these operators, more specifically those that were sustainable or traced. It has not been simple because there were some people who were born in 1930/1935. The company has made available technicians and agronomists to teach suppliers how to use the portal, but in most of the cases it has met suppliers halfway and it has inserted data provided by farms or crushers by itself. At the beginning of the project it also provided training sessions reserved to qualified personnel.
Collaborations and partnerships can be useful to develop the project. The company collaborates with the University of Bologna, the School of Italian Cuisine, the FAIFondo for the Italian Environment, the Symbola Foundation, Legambiente and the University of Gastronomic Sciences of Pollenzo.
As far as the supply chain project is concerned, in July 2017 the company organized a meeting with the representatives of the institutions, the control and certification bodies and the operators of the sector to discuss how to support and valorise biodiversity and sustainability in the Italian extra virgin olive oil supply chain both in Italy and abroad.

Technologies implemented at the production plant level

At the plant level everything is atomized. The company's automation system has been running for 15 years. There was the need to implement a system like this because of the volumes produced. Thanks to technologies risks have been reduced because the most critical points are easily identified.
The last purchases in terms of technological machinery are linked to sustainability and they aim to reduce the environmental impact.
The company has decided to equip itself with a new cogeneration machinery. Co-generating means producing energy together. In this case, thermal energy and electricity at the same time. Thanks to this system, it is possible to produce the two types of energy through a single system, powered by a single primary energy source.

It was developed by CGT SpA. Thanks to this adoption, the company achieved its objectives in just four months. In fact, the machine allows the optimization of the production, from refining to bottling, and it limits the environmental impact.

The machine consists of an internal combustion engine fuelled with natural gas. It has a net electric power of 1200kWe and 2748kW of thermal power introduced by fuel. The thermal power produced and recovered by the machine is equal to 1290kWt, with the engine running at maximum load. A system located on the machine engine transforms the thermal energy contained in the exhaust gases into hot water at 95 ° C and into steam at 13 bar. Hot water and steam are employed to foster the refinery processes.

This project is environmentally friendly. In fact, it allows a significant reduction of polluting gas emissions. Furthermore, a greater energy efficiency linked to a cogeneration yield of over 85% leads national savings in the supply of fossil fuels due to a more efficient use of energy source. It has been demonstrated that fossil fuel consumption has decreased by 30% after the machinery implementation.

There are also economic advantages. In fact, the machine allows the production of energy at lower costs and there is also the possibility to take advantages from the incentives provided.

This machine has been designed to be completely soundproof thanks to the use of special covers that are able to contain the acoustic emissions of the engine and the rest of the system.

Cogeneration machines of this technological content require high levels of professionalism and competence, not only in the planning and commissioning phases, but also in the operational phase, when the machine works. For this reason, the company has decided to rely on CGT, signing a 24-hour assistance contract for 10 years. This maintenance service represents a security for Oleificio Zucchi. Technicians will be available 24 hours a day, 7 days a week. The employees have just to call the toll-free number explaining the problems. Technicians will try to provide a diagnosis and a possible remote solution. If the problem can't be solved in this first phase, the specialized personnel will intervene from the nearest operations centre directly on the machine, thus maximizing production hours and reducing production downtimes.

In 2017 the company bought new heat exchanges. They are employed during the refining process at the moment of the degumming and polishing phases to recover hot water from the cogeneration plant.
In 2017 the company also changed the furnace because the previous one had an obsolete technology. The new one was developed by Mingazzini/Rotogy and it is characterized by a new combustion technology which provides a better performance.

Suggestions for the future

The main objective of future strategic decisions and investments will be to encourage customers to be curious, because if a consumer is curious, he is aware and if he is aware he asks for quality and the company can guarantee it.
Ms Novelli suggests to invest in technology to offer customers certified products and to pay a major attention to the environmental impact. This is what the market requires. Being competitive requires making investments in this direction. The company has a competitive advantage compared to its competitors because it offers customers a completely traced and certified oil and customers like this. "Filiera 4.0" project will reap the rewards over time. It has allowed the company to make its business known to consumers by offering verified products and by satisfying more conscious consumption choices. This is only the first step. In the next years the objective will be to develop a European extra virgin olive oil supply chain.
Furthermore, thanks to the other investment choices, the company can benefit from its image as a non-polluting firm.

Res Uvae

The experimental-demonstrative company Res Uvae is located in the heart of Val d'Arda, not far from the medieval village of Castell'Arquato (Piacenza). It was established in 2015. It has only three fixed employees and it is directed by the oenologist Federico Rossi and two other companies, the former is a firm which deals with innovative techniques in the viticulture field and the latter is another wine company, named “La Ciocca”.

Mr Rossi considers his company as a demonstrative firm rather than an experimental one because it was established with the objective to test the most interesting and innovative solutions available in the market which can benefit wine companies: sensors, models that support the decision making process, techniques to work the land, different types of treatments, everything related to a more sustainable viticulture. Innovations concerning machinery, meteorological stations, sensors and decision support systems are tested on a company scale. Res Uvae also tests products such as plant protection products, fertilizers and biological products. It can be considered as a center of viticulture extension: its mission is the transfer of new knowledge and technological innovation coming from scientific research through the involvement of farmers and technicians according to a participatory and experiential approach. It is a technical demonstration company also because visits are organized over time to show the results obtained.

Its vineyards cover an area of about 15 hectares. Different wines are produced, from the local Barbera, Bonarda, Malvasia and Ortrugo, to the international ones, such as Cabernet Sauvignon and Merlot. The wines produced in Res Uvae are characterized by three different territories: the red lands of Castell'Arquato, typical of red wines with a great body and excellent aging potential; the calcareous soils of Val Chiavenna, from which white wines characterized by great harmony are derived and the Travazzano clay soils that offer soft and long-lasting wines with very complex olfactory sensations.

The turnover is about 150 thousand euros and the company exports mainly to Eastern countries: China, Mongolia and Japan. The eastern countries appreciate still wines, so those which are destined to export are Malvasia and Cabernet Sauvignon. Res Uvae doesn’t sell only directly but it also operates in the B2B market, as it supplies wines to bars and restaurants.

	2017	2016	2015	Variation %
Turnover	€150.436	€144.323	€22.022	683%

Studies and experiments are carried out in collaboration with universities and suppliers of technical means. At Res Uvae there are all the facilities to make experimental and demonstrative tests according to the most rigorous scientific approaches. Some pilot sites have been set up to test technological innovations on a large scale and in the medium term.

Technologies and projects developed at Res Uvae

The collaboration with Horta srl (which is a Cattolica University spin-off) started in 2015 because the company wanted to give the idea of a demonstrative firm from the beginning. The collaboration started with the implementation of some meteorological stations linked to a Decision Support System. This system provides the company agronomists useful information for a sustainable management of the vineyard.

A Decision Support System (DSS) is an IT platform that collects real time data through sensors and scouting tools. After that, it organizes data in cloud systems, interprets it using advanced modeling and big data techniques, and integrates it automatically, providing information, alarms and support to the decision making process.

Res Uvae DDS is called Vite.Net. It is a system which takes real time data from the meteorological station. Data is related to temperature, humidity, leaf veiling and wind speed. This data is sent to a server that verifies it and forwards it to the mathematical model which provides alarms and indicates when vineyard should be treated. Thanks to the weather forecast and data provided by the meteorological stations, it’s possible to know if there are optimal conditions for the development of diseases and consequently oenologists know when and where to distribute treatments against Peronospora, Oidium and Botrytis, which are the main diseases to which plants are subjected. In fact, the company performs the treatments only in case of "high risk".

Therefore, these models are used to face the main adversities in order to make the right treatments at the right time. Within this model there is also a list of products that can be used, a model of soil rotation and an irrigation model which indicates the amount of water available within the soil.

The company has taken advantage of this technology in terms of savings in field treatments, thanks to an accurate and precise analysis of the state of the vineyard. This has resulted in economic savings in terms of production inputs as well as in terms of working hours. In fact, Res Uvae saves about € 300 per year per hectare.

The company has also taken part to other innovative projects, some of them are:

- Nutrivigna project
- Soil4Wine project
- PRO-VITERRE project.
- Trap-V project

Nutrivigna project was developed as part of a trial between Cattolica University, Haifa and Terrepadan. This system gives plants the correct nutrients, respecting the correct dosage and composition. Specifically, it aims to determine the mineral needs by proximity and remote sensors and to define systems to manage the vineyard with a lower environmental impact.

Another important project is related to the development of a subsurface drainage system as part of the European LIFE project called Soil4Wine. It has been implemented to allow the deep disposal of excess water. Thanks to this system it is now possible to study the effects of soil management and fertilizers on land erosion, on loss of organic matter and nutrients and on the presence of residues of plant protection products and other phytosanitary products in the dripping water. These aspects are fundamental to evaluate the vineyard management techniques not only under a productive and qualitative prospective but, with a 360-degree approach, considering also the environmental sustainability of the production processes.

PRO-VITERRE project is an initiative carried out under the regional rural development program 2014-2020 with the aim of introducing new techniques to obtain quality wines while preserving the integrity of the land. The company has joined the project because its vineyards are characterized by problems like soil erosion and lack of organic substances. It is also very interested in the sustainability issue and it believes that soil health is fundamental for guaranteeing a future for both Italian viticulture and plants.

Trap-V has been designed for the monitoring of different insects in agriculture including the Lobesia Botrana. It is sufficiently light to be hung and positioned where there is need for monitoring, it is self-sufficient thanks to its rechargeable battery via solar panel. It is also equipped with multiple cameras that take high-resolution photographs of the collar plate and to be sent via GPRS to the platform. The data, collected in real time, can be accessed via PC or mobile devices and can be stored for further future analysis.

Difficulties met in technology development

According to Mr Rossi, there aren't entry barriers. The most difficult thing is the Italian mentality. In his opinion what is required is a mentality change. Old mentality winegrowers have always performed treatments according to schedules and calendars, nowadays these techniques should be over overtaken. According to his experience, in the past, wine growers looked at the sky to forecast whether conditions, "*There are clouds, it will probably rain, so it's better not to make treatments*". Thanks to the new technologies, this is not necessary anymore because the wine grower knows exactly what plants need.

Res Uvae started from the purchase of three meteorological stations, as it has three different lands characterized by different soil and wheatear conditions. It was not a really expensive investment because each meteorological station is 1000€. After that, they started to implement the mathematical model and they added a probe within the land at 20, 40 and 60 cm deep, to measure the humidity of the soil.

All these tools considered, the initial investment was 5000€. For this reason, according to Mr Rossi, the investments required in the agricultural field are affordable also to small companies.

The company has not taken advantage of regional or European funds yet. Mr Rossi didn't know of any subsidy financed by Emilia Romagna region to buy meteorological stations, sensors or DDS. According to him, supports which are promised are more on paper and they hardly materialize in real assistance.

Advantages

After the implementation of new technologies, it's hard to affirm that productivity has increased because it takes time. Two consequences of technology are improvement in the quality of the grapes as well as economic savings.

The company has saved money in terms of plant protection products, and in term of the cost of the operator who makes the treatments. Another advantage provided by technology is that the company is more environmental sustainable.

When wine growers are asked what are the main advantages of technology implementation in the vineyard, most of them answer that quality improves. This is a common result. In Res Uvaes case, it is linked to the fact that viticulture 4.0 makes it possible to establish the exact quantity of water and nutrients necessary for crops. As a consequence, plants are treated only when they need. For example, 2017 was an extremely hot year and only irrigation has allowed to obtain a satisfactory result in terms of quality, production and income. Where this practice has been accomplished thanks to the installation of drip systems, results were even better because of water and nutrients savings.

Future predictions and suggestions

The company's future plans are very ambitious. Mr Rossi wants to go on working on mathematical models to support the decision making process by improving its capability to forecast the plant productivity. Furthermore, the company will start to implement precision agriculture tools, such as satellite systems that can better improve the company's performance and decrease certain types of costs. According to him, the next step in the viticulture field is precision agriculture: maps of force, drones, satellite driving systems, variable rate fertilization methods based on maps of force.

The partners with whom Res Uvae will implement these new technologies will depend on who will be the authors of these systems and improvements. The firm always look for innovations together with others, such as service providers, or the machine suppliers, so that it can try and find solutions to the emerging problems. Surely if there is the opportunity, Res Uvae will continue to work with the Catholic University of Piacenza.

Mr Rossi suggests other companies which have not invested yet, leave behind an older mentality and move on to innovations, as it happened in the electronics world. According to his view, it's fundamental to understand the next step, so the whole world should innovate, starting with the oldest winemaker to the younger one. What is needed is a change of mentality because the investments required are not high and they allow producers to save more than they spend.

Guido Berlucchi & C.

In the 50s, Guido Berlucchi produced a white wine called "Pinot del Castello" in Borgonato. The wine was named because the grapes came from his small manor's vineyard. To overcome the shortage of wine, he consulted the oenologist Franco Ziliani. Ziliani proposed him to create a sparkling wine using the French manner. Ziliani and Berlucchi joined the insurer Giorgio Lanciani, a friend and colleague and Guido Berlucchi & C. was established in 1955. After six years of experimentation, in 1961 the first three thousand bottles of "Pinot di Franciacorta" were created and they were to be the forefather of all the local production.

Guido Berlucchi disappeared in October 2000. He left his stake in the company (31%) to a foundation which gave its shares to Franzil, Franco Ziliani's financial company in July 2016.

Berlucchi's vineyards, now totally converted to organic viticulture, cover over 500 hectares, between estate vineyards and those in the hands of trusted, long-term growers. The company employs about 105 employees and it has an overall turnover of 40 million euros. The percentage of export is 18% of the turnover. The company exports to USA, Japan, Germany, Great Britain even though the most important foreign markets are USA and Japan.

	2012	2014	2017	Variation %
Turnover	€35.566.235	€39.442.892	€39.922.612	12,24 %

Initial steps before investing in viticulture 4.0

Guido Berlucchi & C. is an interesting case study because even if only 1% of the Italian soil is cultivated using precision agriculture techniques, it is investing in technologies and it is taking part in different projects to improve methods of production.

The company entered the world of Agriculture 4.0 in 2000s because it needed precise and objective data. Making evaluations and comparisons in agriculture is extremely complicated because of soil and climate conditions variability. Precision viticulture helps to collect absolute data which can be compared.

Anyway before investing in viticulture 4.0 is fundamental to know the own soils and vineyards. Making evaluations requires considering different aspects, such as the previous history of the vineyard, the variability of the soil as well as the different climate conditions. For this reason, the company, before investing in such technologies, has equipped itself with expert technicians and oenologists able to read and analyse data. Another important aspect to consider is the way in which technology should be considered. Winegrowers shouldn't expect that machines and sensors will do all the job.

The oenologist Cortinovis underlined that a big mistake is thinking that precision viticulture can replace the human eye, it is only a useful added tool and it must be interpreted, it does not give answers. Therefore, skilled personnel are needed because each situation is different form the others as in viticulture there are many variables.

This case study teaches that training and awareness of the tools implemented are fundamental elements before investing in viticulture 4.0.

Technology in the vineyards

In 2003, the company acquired the first maps of force from satellite, together with the company Casella, a manufacturer of agricultural machinery and Studio TerraDat.

At the beginning the maps of force were acquired thanks to a satellite, then the company started to use a biplane. In 2010 drones started to be implemented but after an experimental period it moved to the proximity sensors installed on agricultural vehicles which pass through the rows for the treatments. The company changed towards proximity sensors because drones take a series of pictures of the vineyard that must be processed and 'stitched' together. This takes time and resources. Furthermore, when Guido Berlucchi & C. started to use them, the ENAC[2] legislation was still unclear and therefore there were many uncertainties about how and where drones could fly. However, the main problem with drones is their detection area. Flying at 50-100 meters the picture's diameter is limited. Drones should have more extensive autonomy and higher operating shares, but this is also influenced by the ENAC legislation.

Nowadays the company harvests differently within the same vineyard, it fertilizes in a variable rate and it plants new vineyards choosing where to place a rootstock relying on

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[2] ENAC stands for National Agency for Civil Aviation and it is the Italian authority for technical regulation, certification and supervision in the civil aviation sector under the control of the Ministry of Infrastructure and Transport

the maps of force. In this way it places the rootstock which is most suitable for the specific soil, avoiding fertilizers in a second time.
The company is working on a European project called Life, in collaboration with other firms and the Milan University. The project is about the creation of an organic fertilizer spreader. Specifically, this machine is able to dose the quantity of fertilizers or organic materials. The machine's valves open and close automatically relying on data acquired throughout the maps of force. This step has been taken because many companies are switching to organic agriculture and as a result, chemical fertilizers can't be used and therefore both the distribution and the techniques must change. Furthermore, a variable fertilization is better than a constant dose because plants' needs are not all the same. The variable fertilization allows to supply plants with the exact quantity of fertilizer they need, without waste.

Advantages and difficulties

These new techniques allow the company to benefit from several advantages. First of all, maps of force give precise data which supports the decision making process.
Secondly, they allow savings of costs and resources. Having more tools that represent a real situation means distributing less fertilizer, or distributing it where it is actually needed, and where there is no need, not distributing it.
The third advantage is linked to sustainability. In fact, these new techniques reduce pollution because if fertilizer is distributed only where it is needed, less fertilizer will be distributed and this generates less pollution.
Mr Cortinovis summarizes the advantages obtained by his company highlighting three main points:

- rationalized costs;
- homogenized land;
- no surprises in the wine cellar

As far as cost saving, it is difficult to have a precise figure. The company saves around 15% or 20% in the management of the land but cost saving is a consequence not the main driver of the investments. In fact, viticulture is different from agriculture. According to Mr Cortinovis, in agriculture we can talk about quantity and productivity whereas in the viticulture field we look at quality.

Guido Berlucchi & C. has always focused on quality, in fact it has chosen very dense planting systems, with 10 thousand plants per hectare. It has limited production, about 900 grams per vineyard, because it has preferred a quality production. Quality is perceived differently from firm to firm and consequently it's difficult to evaluate if a wine is better than another and consequently making considerations about costs is difficult. Probably it's easier to evaluate costs in a cereal company, where standards are linked to productivity.

The main obstacle to the development of Viticulture 4.0 in Italy is the fact that we have different soil and weather conditions as well as several types of wines and vineyards. In Italy there are more than 3000 types of wines and this makes comparing data difficult. Maps of force have become a powerful instrument in the Franciacorta region because it is a small and homogeneous area, where only two types of wine are produced: Chardonnay and Pinot Nero.

The oenologist Cortinovis suggests to collect public maps of force and to make them available to everyone in order to solve the variability issue. This data could be included in the GIS platforms, like Siar, as it has been done with the cadastral data.

Investments required by viticulture 4.0 are not so expensive and they can be supported by small and medium enterprises. The amount to pay to have a map of force has decreased over time. Nowadays it costs 30 or 40 euros, so even the smaller agriculture companies can afford it. For this reason, all the Italian wine firms should start considering these new techniques. The first step is to acquire some data (some maps of force of some vineyards) and go to the vineyard with the map trying to translate the data.

They shouldn't rely completely on these tools, but they should begin to understand if the answers they have on the paper are congruent with the activities that are carried out on a daily basis.

Guido Berlucchi & C. benefits from European projects which are financed by Europe. At the beginning it was more interested in general projects but nowadays it is focusing on specific ones, such as researchers about a single vineyard to study different aspects.

Technology is considered an instrument to support decision making. It's not perceived by the company as something that will substitute human work. According to the oenologist Diego Cortinovis, oenologists should use maps and other instruments as tools, but they shouldn't make decisions only considering this data.

For this reason, technology has not changed dramatically the work which is done within the company. Winegrowers and technicians still need to go to the vineyards and they still do all the things they did in the past decades.
Technology is changing the skills required. In the future specialized technicians and oenologists will be needed and schools should be aware of this. According to the oenologist Cortinovis it is a utopia to think that technology will substitute humans in the future.

CONCLUSION AND REMARKS

This study has tried to understand the changes brought about by new technologies within small and medium-sized Italian agri-food firms. To achieve this goal six case studies were analyzed.

Based on the analysis, some common situations can be identified. In particular, the implementation processes these business undertook, their reasons for developing these implementation processes and the difficulties they have experienced are all similar.

Concerning their motivations, the study revealed that these agri-food companies moved to become Smart agri-food producers in order to improve quality, enhance sustainability and to decrease costs.

Several scientific papers from the literature surveyed have highlighted that technologies improve quality particularly with regards to the valorisation of the origin of products, the guarantee of production processes and food safety. Technology has an impact on quality because most of the manual work has been replaced by machines and software which speed up processes and decrease the error rate. As the Astoria case study demonstrates. Wine's quality highly depends on the filtration process and consequently this is the phase in which technologies have been implemented most extensively. Astoria uses a by-pass filter machine to filter wines in an automatized and remotely monitored way.

As explained by Mr Salvagnin, quality is more significant than productivity in this sector. In fact, selling prices depend on quality rather than quantity. Quality is measured differently from product to product, and standards are not homogenous.

Making evaluations and comparisons in agriculture is extremely complicated because of the variability in soil and climate conditions. Smart agri-food helps producers to know better soils and this is fundamental to production of better products because absolute data can be collected and compared. For example, the major problems with production of corn are related to drought and aflatoxins. Società Agricola Porto Felloni employs probes and sensors to monitor their levels, ensuring products of greater quality.

Enhancing sustainability is a fundamental requirement for customers who look for organic products which should be produced without polluting the environment. This fact can be explained by the analysis provided by Nielsen Holdings Inc. Based on this analysis, the customer profile that grew the most in the last three years is the Golden Shopper (i.e. +5,4%). These customers look for quality products guaranteed by geographical and organic certifications. They pay attention to both tangible and intangible elements, such as ethics. Companies are adapting to this new trend, as demonstrated by Berlucchi & C. which has totally converted to organic viticulture.

Ms Novelli from Oleificio Zucchi suggested investing in technology to offer customers certified products and to pay greater attention to environmental impact because this is what the market requires.

Concerning costs, technologies help companies to save money, time and effort. Technologies digitalize processes so less operators are required to perform the same tasks. Manual and repetitive work can be performed by machines meanwhile workers may be assigned more creative activities. This is the reason why Astoria decided to substitute its filling machine.

Agriculture 4.0 also allows for savings in the use of machinery. Self-driving tractors, machines and sensors decrease movements within fields by 10%/15%, reducing machine, fuel and fertilizer consumption as well as staff hours.

As far as implementation processes are concerned, companies have entered slowly into the Smart Agrifood world. It wasn't an overnight change; it was a thoughtful and considered approach. Many of the analyzed companies started to adopt technologies thanks to work with contractors. Società Agricola Porto Felloni asked contractors to make maps of force. This was the cheapest and fastest way to map its soil. Alternatively, it had to buy instruments and software, train employees and technicians and this would have required time and effort.

This study has revealed that most of the agri-food businesses took advantage of rural development programs provided by the European Union. They foster cooperation among companies, researchers and universities and this boosts knowledge transfer. Latteria di Soligo managed to develop the Safetypack system thanks to a European project. In addition, European programs allow economic savings as demonstrated by Società Agricola Porto Felloni, which saved approximately 35%/40% of overall costs.

Difficulties met in the implementation process are also related to people. All the people interviewed underlined the need for a change of mentality. For ages, agri-food businesses have performed treatments according to schedules and calendars. Human labour has been considered the most suitable for agricultural purposes for many years. As underlined by Krishna (2016), the delay in developing agricultural robots was due to the difficulty in designing and constructing safe, reliable and easy-to-operate robots. Furthermore, the easy availability of human labour dissuades many from even thinking about robotics in crop production.

The Ismea report (2018) pointed out that people working in this sector are usually older compared to other sectors, especially in the case of oil or agriculture (i.e. in 2013 for each entrepreneur who was younger than 35 years old, there were 12 entrepreneurs who were older than 65). As a consequence, many workers don't know technology and it's not possible to teach them or to make them understand the advantages provided by it. Oleificio Zucchi developed the Filiera 4.0 Project to ensure online traceability of its products. All the information related to its oils is available in a portal. The company asked suppliers to insert data within the portal recognizing economic rewards but most of people working at farms or crushers didn't know how to use the web. So, the firm inserted data on its own. Furthermore, interdisciplinary skills are missing today. According to Mr Salvagnin, what is essential is the understanding of the link between agronomy and cartographic solutions. The majority of agronomists don't want to dialogue with new solutions even if there was the need.

43,540 employees are expected to enter food businesses by 2021. New employees should have more interdisciplinary skills and they should be open to learn. In the last years, training hours aimed at supporting digitalization of agri-food firms were 6.673 out of a total of 37.621. This figure is not so significant numerically because the incentives provided by the "Calenda plan" had not been launched yet when training plans were presented; therefore, companies didn't need to take part in training programs. Surely, this number will increase in the next years because training is a fundamental driver for the sector's competitiveness.

All things considered, technology shouldn't be perceived as something that completely changes the way in which work is performed. It's an instrument that helps agronomists, winegrowers, entrepreneurs and technicians to make decisions to achieve greater economic performance, have a sustainable practice and offer fresh, safe and tasty products to demanding customers.

Technology is changing the skills required as well as the interconnections between businesses. Experts from different backgrounds are asked to cooperate and to exchange ideas. Res Uvae believes strongly in this idea and it works in collaboration with researchers and universities. All the technologies implemented by the company were developed together with partners from different fields (e.g. academic). Agri-food businesses should take Res Uvae as an example: this demonstrative firm always looks for innovations together with others, such as service providers, machine suppliers, and universities so that it can find practical solutions to emerging problems

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