INDUSTRY 4.0 AND ITS CONSEQUENCES FOR WORK AND LABOUR

Field research report on the implementation of Industry 4.0 in a sample of Italian companies

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A special thanks to FIOM-CGIL, its local structures and to workers' representatives of companies involved in the present research for their crucial support

CONTENTS

CHAPTER 1

Introduction and General Framework

1.1 A BRIEF INTRODUCTION TO THE PROJECT: THE PRESENT EUROPEAN INDUSTRIAL STRUCTURE

The present analysis can be framed into the conceptual framework of international fragmentation of production – or global value chains, or supply chains.

Global markets integration and trade and capital movements liberalisation triggered fragmentation of production processes, with more and more multinational companies spreading production stages in different countries – or externalising some of these stages via sub-contracting relations with foreign companies. This strategical choice is of course led by profitability, i.e. the possibility of taking advantage of lower wages and other production costs [Feenstra, 1998].

In this way, countries specialise in particular production stages. This generally happens when three conditions are fulfilled: 1) production activity takes place through multiple sequential stages; 2) one or more countries specialise in some, but not all of such stages; 3) at least one component crosses borders [Hummels et al., 1998].

Input-Output techniques are very well-suited to study this kind of phenomena, especially thanks to the recent compilation of multi-countries IO data models such as WIOD [Timmer, 2012; Timmer et al., 2015]. In fact, a huge strand of literature took advantage of this analytical tool to study different aspects of international division of labour.

Some authors used IO tables to indicators of internationalisation such as (total, i.e. direct and indirect) import content of exports [Breda et al., 2008]. An application for the case of Italy and Germany for the 1995-2006 period can be found in [Breda and Cappariello, 2012].

Other authors studied the international composition of global value added, by describing the way in which industrial sectors in specific countries behave as the head of the corresponding production chain: domestically produced final goods and services are either sold domestically or exported; at the same time, their production process absorbs intermediates produced both domestically and by foreign countries.

By measuring the ratio of value added to gross exports (i.e., including intermediate commodites imported as inputs to produce exported commodities), they estimate that: 1) it varies widely according to countries and sectors; 2) the value of exports my be 40% lower when estimated in this way (see for instance the case of US and Canada) than with measures taking into account gross values only [Johnson and Noguera, 2012].

From the point of view of geographical distribution of production chains, some authors [Los et al., 2013] stressed that: 1) the great majority of European production chains increased their degree of fragmentation, particularly after 1995, independently of the kind of commodity produced and of the country which is the head of the chain; and that 2) both regional (within EU) and global (outside EU) fragmentation increased, even if the latter is the one which brought about the most relevant effects.

Other authors – e.g. Baldwin and Lopez-Gonzalez [2013] – showed that: 1) supply chains show a more 'regionalised' character than trade in final commodities; 2) international supply of services is less regionalised than trade in intermediate manufactured goods 3) supply chains behave according to a 'hub and spoke' model, differently from trade in final commodities. In general, the authors concluded that international production chains for manufactures goods are predominantly regionalised, and hence focused their attention on what they called 'Factory Europe', 'Factory Asia' and 'Factory North America'.

The evolution of the new European industrial structure is based on a process of centralisation – of companies ownership and strategic functions – without concentration: production is geographically fragmented and dispersed [Bellofiore and Halevi, 2012].

In the 1980s, the concept of 'supplier' changed drammatically: it became a new competitive industrial sector supplementing many different branches of industry with specialized tasks and/or parts to be assembled or integrated within a more complex good. A web of possible different relations emerge among the firms that constitute the 'supply area': these networks of suppliers – or 'supply chains' – are segmented in tiers and poles.

This leads to a new social division of labour in Europe: an integrated industrial system with uneven territorial distribution of core competencies and corporate headquarter; the companies of the eastern countries of EU are mostly under the control of western corporation. Supply chains are more integrated than in the past, and the companies engaged in the upstream activities are in some way under the authority of the firm controlling the specific supply chain as a whole (OEM), or of the other key players in each tier. This means that the key players decide for other companies on how to plan output quantities in a given period of time, on the pace and speed of deliveries, etc.

The degree and the nature of network integration is such that the border lines between companies blur and new ways of cooperation start with original corporate governance schemes. These webs of firms sharing a production process are a comprehensively integrated process. They can organise their network utilising all kind of diversity of legal, fiscal, social obligattins, as well as of skills and competencies availability, as way to fine-tuning their internal division of labour.

This new industrial environment leads to a high level of fragmentation of each economic activity and therefore to the fragmentation of the working class and to the weakening of trade unions all over Europe.

Integrating these complex production chains is very hard, since governance must concern both the material control of produced commodities (their quality, delivery times, flexibility, quick reaction to shifts in demand, etc.), and the economic/financial performance of companies at the head of the chains themselves. When talking about processes based on independent segments, overall efficiency is determined by the efficiency of each single segment and by the ability to fine-tune the overall operability of the chain: new business models, based on ICT, allow complexity to be governed; the transformation of these chains into into Cyber-Physical Systems (CPS) should make great improvements possible [**?**].

In Italy, the subject of networks gave rise to a lively debate, due to both the phenomenon of productive decentralisation, which has been especially marked since the end of the 1960s, and the presence of industrial districts. Augusto Graziani [in Monte and Raffa, 1977, *Introduzione]* described the industrial restructuring which took place in Italy over that period, with all the action taken by the capital to recover and increase profits. One of the key element of such a restructuring process was the externalisation of various production stages in order to reduce production costs and increase flexibility in meeting demand shifts. Italian Trade Unions reported this practice as anti-working class, i.e. aimed at escaping the enforcement of collective agreements and workers protection law. According to Graziani, this was the reaction of Italian companies to economic improvements obtained by Trade Unions following the fights in 1969 and to regulatory improvements introduced by the Workers' Statute (Statuto dei Lavoratori) in 1970. In this way small business, recipient of production stages externalised by big business, became fully functional to the development of capitalistic development. The study by Del Monte and Raffa showed that productive decentralisation in the 1960s and 1970s was the result of an industrial restructuring based on the extensive exploitation of the labour force. Big business took advantage of small business and homeworking to recover profits, thanks to the exploitation of all margins offered by a segmented labour market, overcoming in this way the limitations imposed by labour force rigidity. Federico Butera [Butera and Dioguardi, 1988] talks about 'network enterprise' ('*impresa rete*'), a concept which includes both big and medium business – when it operates as a strategic agency networking autonomous enterprises – and networks of companies providing themselves with a common governance system. Butera stresses that often the core company integrates its suppliers into its own internal structures through operative systems – planning, reporting, and management information systems. To these elements, one should add the use of information technologies, which in the 1980s included telecommunications, geographical and local networks, collaborative technologies, Decision Support System, etc. In this way, ICT infrastructure was the key unifying element of dispersed subjects.

Other works stressed the link between manufacturing industries and services linked to them. Siniscalco [1982] singled out the existence, within services, of the so called 'tertiary for the productive system' (*'Terziario per il Sistema Produttivo', TPS*), i.e. of services mainly oriented to production for intermediate rather than final demand. The weight of TPS to total services strongly increased in the decade from 1965 to 1975, going from 31,9% to 36,3%. More specifically, services saw an increase in their integration to manufacturing industries; in their turn manufacturing industries increased their tertiarisation. The services most integrated with manufacture blocks were credit, research, transport activities, communications and services to enterprises. This study – followed up by other researchers such as Rampa [1985, 1986] and which is worth being updated – shows how, despite the dominant narrative, a great deal of services sectors are not replacing manufacture, but rather strictly connected to and triggered by it. Productive decentralisationcan also be directed towards foreign countries: in this case, it is more appropriate to talk about delocalisations (offshoring). In this framework, productive decentralisation, network enterprises and delocalisations appear as strictly connected phenomena. According to the definition provided by the World Trade Organization [2005], offshoring is a particularly common kind of outsourcing (externalisation). The latter is defined as the practice of externalising production stages, formerly carried out internally, to external contractors. The same report classifies outsourcing according to two criteria: (i) ownership – supply agreements concern companies under the same ownership or not; and (ii) geographical location – supply agreements concern companies located in the same country or in different countries. Applying these criteria four kinds of outsourcing have been identified:

> 1. Captive onshore outsourcing implies a shift in intra-firm supplies to an affiliated firm in the home economy.
> 2. If the shift in sourcing of supplies benefits a non-affiliated firm in the home economy, one can describe it as non-captive onshore outsourcing. The term 'onshore' could be replaced in both cases by 'local' or 'domestic'.
> 3. Captive offshoring describes a situation in which future supplies are sourced from an affiliated firm abroad.
> 4. The fourth variant of outsourcing may be labeled non-captive offshoring and refers to the case when the new supplier is a non-affiliated firm and located abroad.
>
> [World Trade Organization, 2005, p. 310]

A broad literature exists about global value chains (GVCs); in particular, according to the World Trade Organization [2014], it is not an entirely new phenomenon: "What is new is their increasing scale and scope, involving a complex organization of inputs, in terms of both goods and services, from many countries." (p. 121). The report also stresses some critical issues: "GVC participation also holds risks. It exposes countries more strongly to global business cycles and to supply disruptions in far-away locations if these produce crucial inputs into production. The fact that it is possible to integrate into a GVC with a relatively narrow set of skills implies that competitive advantage becomes more fleeting and that the risks of industries relocating are higher. Competition to attract new investments exposes countries to a potential race-to-the bottom on domestic regulation. Finally, GVCs may increase income inequality as high-skill individuals' relative remuneration tends to rise and the share of profit in output increases relative to that of labour." (p. 122).

Briefly focussing on the automotive sector looks useful at this point, since a) this sector is organised as a set of complex, geographically dispersed supply chains; b) these chains are international; c) it is one of the sectors most interested by the phenomenon of Industry 4.0. Timmer et al. [2015], using the World Input Output Database (WIOD), showed the characteristics of German automotive GVC. Firstly they define "a GVC of a final good as the set of all value-adding activities needed in its production. It is identified by the country–industry in which the last stage of production takes place, which we call the country–industry-of-completion (such as the transport equipment manufacturing industry in Germany). A GVC includes the value added in this last industry, as well as in all other industries in the same country or abroad where previous stages of production take place." The authors decomposed total value added generated by German automotive GVC to identify its geographical origin. They found that, between 1995 and 2008, the proportion of domestic value added decreased from 79% to 66%: Germany, in fact, delocalised a relevant part of the production process to take advantage of lower labour costs in Eastern Europe. In the same period, all the main car producers, with the exception of Canada, showed a decline in the proportion of domestic to total value added; for European countries, this ratio is between 60% e il 70%. In the case of European automotive chains, in 2008 the proportion of value added generated within the EU is higher than that of value added generated in the rest of the world; however, the latter ratio increased faster than the former in the above mentioned time period.

1.2 A SUMMARY OF THE POSITION PAPER

We aim at contributing to the definition of a political and theoretical framework to interpret the processes of production and labour digitalisation – Industry 4.0 and platform-based capitalism – for labour-oriented organisations. Our point of view focuses on the relations between technology and social dynamics. The one taken here is not a deterministic approach: we do not think that technologies are exogenous to the social structure, but rather that technological trajectories are embedded in social relations.

It is worth pointing out that technologies are not neutral, but they are open to certain social options and closed to others; in other words, they are the result of implicit or explicit social choices.

We will, therefore, start from social relations of production, in particular from the emergence of a new form of capitalism and a new productive structure. We start from the point of view of the workers. However, we cannot confine ourselves to a strictly analytical approach, but we need to utilize a normative approach to intervening on goals and forms of this process, and not only on its consequences. The questions are: how can we design systems suitable for people? Today here is a revival of this approach of the seventies namely in Germany. Within the second approach, the question is: how do we make it possible for people to design their systems themselves? This approach is the tradition of participative design, which is still present in particular in Northern Countries.

We will start from the rise of a new capitalism and its ’political demands’ of the adaptation of our societies and institutions to its needs. A long transition towards more customised products was born in the core of capitalism:

1. to avoid the trap of ’commodification’.
2. Because of the need for reproduction on an extended scale, which in the presence of saturated markets can only be achieved by ”deepening” the existing ones. The deepening can be done on the one side by inducing consumers to demand customised variations of traditional products – often concerning their aesthetics only – to speed up products replacement. On the other side, by the commodification of aspects of social and personal life formerly excluded from the process of value creation. An example is given by new services, usually connected to free time and entertainment which, thanks to digitalisation and the internet, can be supplied through physical objects such as smartphones. The supply of such services also increases the intrinsic value of the physical object itself [Bryson, 2009].

This higher intrinsic value of hybrid commodities needs the development of integrated production systems. It is a brand-new kind of integration. It is no more restricted to the functional supply chain of the physical 'support', but it should scale up to a so-called industrial eco-system, that is a web of different economic, financial and industrial sectors.

This entailed the development of hybrid production systems in which goods and services converge. The clear distinction between different sectors, the separation between goods and services, the forms of oligopolistic market power, are bound to dramatically change on traditional forms of organisation of production under the pressure of these hybrid systems. As a consequence, new forms of articulation of productive activity do emerge, ranging from networks of integrated companies to actual industrial ecosystems, the most apparent example being mobility. [Kelly, 2015].

The need for a more and more radical flexibility, therefore, combines with the problems connected to the increasing integration of these production chains. Flexibility does not concern volumes of production only, but also the composition of the final product which is the result of the convergence of several parallel production processes. There also is an increased necessity for a reduction of the time-to-market to speed up products rotation as much as possible.

Customisation does not concern the intrinsic characteristics of products, but also their very fruition. It is, therefore, possible to separate the ownership of a good from the services it can provide; this leads to the creation of new business models such as Uber o Airbnb.

Full mobility of capital and increasing global industrial integration have triggered a process of centralisation, in Marxian terms, of industrial governance, coupled with an increasing geographical dispersion of production chains. The dispersion generated a deep fragmentation of labour with workers in competition with each other.

Social fragmentation and subsumption of labour to finance turned power relations between capitalists/managers and labour upside down. In the workplaces, this meant a restructuring of labour processes aimed at achieving the maximum development of relative surplus value, the main lever being management and organisational innovation (Lean Production, WCM, etc.). Technology, and especially IT, playing the ancillary role of automating parts of the production process. Managers/capitalists now focus on relational aspects, i.e. relating machines and things on the one side, and these and human beings on the other side. What is at stake now is the process of objectification of the social nature of labour, which Marx mentioned in the *Grundrisse*.

Outside workplaces, the overturning of power relations allowed the emergence of the so-called platform capitalism.

Some of the so-called promising technologies of today such as the 3D printing, also called additive manufacturing, have a long story behind. The additive manufacturing can be considered the evolution of the stereolithographic process by Charles Hull in the eighties.

Network computing has been already in use, and is now following an evolutive path, characterised not only by radical, or disruptive, innovations. The same thing is true for CAD (Computer Aided Design) and CAM (Computer Aided Manufacturing) that are in use since the 1980s. The CAD/CAM technology is the first example of a combination of a physical (CAM) and a virtual process CAD). For this reason, there are people wondering whether this is the case of "much ado about nothing".

But notwithstanding these elements of continuity, we can also talk about elements of radical innovations. The first is the combination of Big Data with Cloud Computing.

The use of Big Data and Cloud Computing can also transform workplaces within traditional manufacturing. The usage of CAD/CAM, although connecting the physical and virtual world, was limited to designers and machine tools operators only. On the contrary, internet of things (IoT) is making it possible to transform labour in manufacturing in its entirety.

If, on one side, IoT and Big Data analytics make possible to develop a data-driven company, on the other side, the recent development of Artificial Intelligence (AI) represents a leap forward. As for other technologies, AI is available for at least fifteen years, but it was a totally different kind of AI. The combination of the *reinforcement learning* with the deep learning makes possible a real leap forward.

On this technological progress is built the possibility of a new 'breed' of robots able to interact with the environment "in a generalizable and predictive way".

Digital manufacturing, i.e. the possibility of simulating an entire production process, makes it possible to save time and resources. Furthermore, industrial logistics, new advanced robotics, intelligent products, and tools such as augmented reality, will contribute to a global transformation of manufacturing and labour.

Vertical integration of value chain concerns the physical control of production flows – quality, timing, flexibility, products mix (services or hybrid); efficiency – productivity, lead time, time-to-market; and profit margins. It requires managing the flows of materials, components, semi-finished products and so on.

The management of this flows problems of coordination, fine-tuning, proportions, and demand-side management. The stock management system is uneconomic because a strong customisation is also needed within large production volumes. Getting the final product requires the interaction of multiple actors in the value chain. In a process consisting of several interdependent segments, overall efficiency crucially depends on the that of each single segment.

Modern management is nowadays assisted by ICT, which allows managing this complexity; suffices to think of how cyber-physical systems might enable huge gains in flexibility and speed up production, improving time-to-market and optimising the use of financial resources.

The digitalization of value chain complies to a logic of integration and operative control by the original equipment manufacturers (OEMs).

Customization brought about the reduction of the batches of production and the necessity of new technical design and manufacturing based on modular and scalable equipment.

All manufacturing processes need of flexibility and costs reduction, which is harder within integrated systems which are characterised by synchronisation problems. In the past, these problems were faced within each single assembly line. Industry 4.0 has to deal with these problems.

Unlike the past, markets are going to demand not only different volumes of output but also different products (customisation).

The most radical perspective is the realisation of cyber-physical systems (CPSs). This will lead towards the reduction of batch's dimension and the associated production costs. Flexibility will be removed from social regulation and control (e.g. by trade unions) and placed in the 'neutrality' of CPSs.

The system would thus have the characteristics of an integrated production flow, not necessarily contained in a single company, which is simultaneously "tense" and flexible. On flexible meaning, we have already said. A production process is to be considered "tense", that is a way of thinking of a production process as a flow of interconnected and interdependent activities, when the different activities are interlinked in the shortest and compact way, according to the lean production criteria. Besides, it should be a direct feedback from the market demand to the production process, according to lean production criteria, so that you can reach both the levelling and the continuous synchronisation of the different parts of the system. We have seen that, unlike in the past, this policy has to deal not only with the quantities required by the market but with the demand for different products in different quantities. The point for the capitalists/managers is that this must be done ”efficiently”. In a single company, this means that you cannot sacrifice to the altar of the need for maximum flexibility the parallel need of the working time saturation. As the engineers of Fiat stated in an internal document, it means that the worker must be ”subservient to the needs of” levelled and synchronised system. In the model of industry 4.0 it is assumed that the tight flow is achievable through the digital connection of the different parts of the production line, not only the one internal to the company but of the entire supply chain; the connection would not only between machines but between machines and men. It would reproduce, in new forms, to be researched, the enslavement of the worker to the needs of the system; needs that would arise less and less as demand from the hierarchy who presides over the production process and more and more like an ”objective” request of a self-regulating system.

Algorithm is a clueless machine which produces important effects on personal or collective issues; therefore, in the age of a widespread utilisation of algorithms to substitute people’s choices it is of the utmost relevance to discriminate a “good” one from a “bad one”.

So, summing up, a “good” algorithm should be open and transparent with its selection of criteria and goals; should be open to correction trough feedback assessed in an open and public discussion, it should be fair to the interests of the people affected and it should do no harm to them. Its domain of application should be exactly and openly delimitated.

The possibility of utilising Big Data analytics can represent a very positive improvement for society and people because of the possibility to find patterns that invisible to human eyes. The issue to cope with is that a pattern can identify a problem but not automatically a constructive solution. A constructive solution requires not only static but also a dynamic analysis of different possible future states of the system objective of the analysis, and eventually a qualitative and open assessment of alternative sets of solutions for the identified problem.

One of the most debated topics, for its obvious social consequences, is that of the degree of substitution, by ”smart” devices, of different professions and/or activities. Quantitative forecasts, critically assessed in the forthcoming literature review, start from some hypothetical assumptions. The first regards the greater or lesser ability to codify the occupational activity. The more, in fact, the knowledge required for that specific activity is tacit (Polanyi) the more difficult, if not impossible, to turn it into a routine and then into codes that can be automated in the sense of Zuboff. The second assumption is that the progress in artificial intelligence and robotics open scenarios of substitution of human labour even in non-routine activities, ranging from the world of production to that of high finance.

The weak point of these forecasts-like those by Frey & Osborne –is their static nature. It assumes that there is a predefined stock of routine and non-routine activities; the latter too are partially replaceable, as in the case of interactive robots. According to the literature review by

Freddi [2017]:

> In particular, lot of attention is currently put on intelligent machines and more specifically on robots and on their (possible) ability to substitute for human labour. This technological advance is typically a process innovation that, as we have seen before, is proven to have a direct negative effect on employment, when studied at micro or meso level. However, macro level studies, although partially weak due to data unavailability and the complexity of the models, showed that there might be compensation mechanisms that could mitigate these effects. Moreover, there is no consensus among scholars on the future effective capacity of robots to fully substitute for human labour, as there some skills such as flexibility, judgement and common sense or the ability to identify the purposiveness of objects that so far showed to belong exclusively to human's skills. If robots have received a great deal of attention so far, the impact on employment of other types of emerging technological opportunities such as for example 3D printing, Internet of Things, Augmented reality, Big data Analytics have not been studied yet. These new technologies offer opportunities not only for process innovation but also for significant product innovation, that a large number of studies proved to have positive employment effects.

In fact, in the case of innovations, including those arising from scientific and technological progress, companies have the opportunity to develop new skills in ways that have been described, in cognitive terms, by Zollo and Winter [1999] as dynamic capabilities, that is "a learned pattern of collective activity through which the organisation systematically generates and modifies its operational routines in pursuit of improved effectiveness." [Zollo and Winter, 1999, p.10]

Thus, for a company, to have that dynamic capability or not to have it is not a "target hit or missed" with an isolated and singular act of creativity, but the availability, or non-availability, of stable structures and/or operational patterns. It is not even an individual mechanism in a strict sense even if it has been set off and conveyed by the people involved.

What happens when an organisation appears a mismatch between what is expected and the result? There are two possibilities:

1. When the error detected and corrected permits the organisation to carry on its present policies or achieve its presents objectives; this is like a thermostat that learns when it is too hot or too cold and turns the heat on or off.
2. when an error is detected and corrected in ways that involve the modification of an organisation's underlying norms, policies and objectives. This is a reflective process. But to be able to access reflective processes, such as those of the critical assessment of the variables, people must, therefore, get out of a defensive scheme, which is as very efficient as it can be deadly dangerous.

The problem is not qualifying the skills only as a fixed stock or to think that the adjustment is just a learning process school-type. There is a dynamic that begins from the re-elaborating of personal and professional expertise in the light of a process of change; the very process of change also must be explained and critically examined. In their conclusions, Zollo and Winter [1999, p.17] state that "[d]ynamic capabilities emerge from the co-evolution of tacit experience accumulation processes with explicit knowledge articulation and codification activities."

This requires organisations to be open to these dynamics, a situation today provided quite exceptional. It, in fact, does not depend on a situation institutionally defined, as in the case of

Mitbestimmung, but from daily working practices. If you choose a digitising perspective that instead of pointing to automation and replacement of human labour using the enhanced opportunities to support workers and to strengthen their capacity for autonomous action and decentralised self-regulation [Krzywdzinski et al., 2016]. The results can also be positive. This depends on how the possibilities inherent in the manufacturing business transformation process are selected, for example whether companies will introduce the new technologies in a gradual or disruptive manner.

In a not fully dystopian perspective, in fact, there are windows of opportunity which should be declined in concrete proposals and objectives to struggle for. From our first field research results, in fact, these possibilities exist when the union is particularly strong. A strong union is unfortunately tied to very specific business situations and are often linked to inequalities between the central enterprises and those of production networks associated with them, that is, corporate labour practices. There is also the historical experience that, even in the opinion of some managers, suggests a cautious attitude on all emphases of full and widespread automation / digitalisation of work, particularly on the assumption of complex, self-regulating cyber-physical systems. This does not mean that cyber-physical systems cannot be realised, as the industrial reality shows us, but as Krzywdzinski et al. [2016, pp.23-24] state that “based on past experiences with automation processes, the degree of process stability produced under laboratory conditions is hardly achieved in practice”; in so doing these processes produce “a very high need for improvisation and creative problem-solving –in a complex as well as simple production processes”.

Unfortunately, past experience shows us that, even when there are not the consequences envisaged by advocates of a dystopian future, a polarisation process will occur producing winners and losers. Krzywdzinski et al. [2016, pp.23-24], after having recalled examples of de-skilling in the previous transformation of the work -the third industrial revolution -, highlight the risks faced by workers with tasks of feeding the machines, those jobs in Germany are classified as ”residual work”, but also workers with high skills: “At the same time, higher-skilled tasks, and increasingly also the indirect tasks performed by skilled workers and engineers, can be made easier, for instance with the help of assistance systems guiding workers by sending them instructions via smart watches or data eyeglasses. Thus, the use of digital assistance systems involves the danger of devaluating experiential knowledge even among workers previously considered highly skilled”.

There are risks, indeed, as well as opportunities.

From the point of view of the employees and their trade union, the first problem is to avoid a choice between prophecies of doom, which serve only to paralyse their collective action, and techno-optimism, which accept the technocratic rule by which the social consequences are the natural and unavoidable effect of the technologies. The cultural and political position more suitable for a strategic defence of workers ‘rights, of developing high levels of employment as well as the right to have a say on all societal processes of change, is that of a full understanding of the political, cultural, social, economic, industrial and technological objectives at stake. Secondly, a field research and a thoroughly monitoring the process of change should be organised, with the help of the people affected by that process.

It is very simple for a research group to draft the above statements on what should be done, but what happens to ordinary people coping with a radical change or, to utilise the trendy wording of this period, a disruption?

We don't know how is the workers' subjectivity situation today. Also at the end of the 80s', there was a clear difference between the young workers who have never experienced a different situation and the older ones. Today we have the Millennials that are digital natives, so it is likely that they will have a totally different feeling? Or some issues are the same? We need research on this. Not the traditional research which considers workers as objects but a kind of research taking them as thinking and feeling human beings.

The field research should be finalised to a constructive process of social shaping of the technologies to develop the so called a human - machine symbiosis, meaning that the capacity of the machines should be used to empower people, in an emancipatory perspective. It is the same perspective by Ehn on making possible for people to design their systems themselves. Today this perspective is out of reach because of the capitalist direction of the process of change. It doesn't imply that these assumptions should be ruled out; they should be assumed as the founding criteria for action.

The monitoring activity is the way to organise a collective action with a strong and stable participation of the employees. Through the monitoring process is possible to design a set of demands based on the daily experiences of the employees involved in the process of change.

1.3 ORIGIN OF THE TERM INDUSTRY 4.0

The term Industry 4.0 was firstly introduced in Germany. Industry 4.0 is a project developed by German government to define a policy framework aimed at strengthen the competitiveness of German manufacture. This strategic initiative was adopted in November 2011 as part of High-Tech Strategy 2020. In fact, German government is pursuing a high-tech strategy since 2006, in order to enforce German competitiveness thorugh technological innovation. The title of the reference document [Forschungsunion and acatech, 2013] is emblematic: "Recommendations for implementing the strategic initiative INDUSTRIE 4.0 – Securing the future of German manufacturing industry". The document was prepared by Forschunsunion and Acatech (National Academy of Science and Engineering) and was sponsored by the German Federal Ministry of Education and Research. The Industry 4.0 project is based on a dual strategy: on the one side, the implementation of new technologies by German companies aims at strengthening the efficiency of domestic production; on the other side, pervasively implementing these technologies requires them to be produced to be sold and exported. Reaching the first goal requires networking the different parts of single production chains, also when located in different plants; in other words, it requires the digital integration of the different stages of value added creation and of products life, and hence a tight integration of the corresponding production systems. From here, the development of the key strategies for horizontal integration of different companies; the digital engineering of the whole value chain; the vertical integration of flexible and reconfigurable manufacturing systems. The second task, in its turn, builds upon the fact that German companies supplying machinery and equipment are in the position to become world leaders in the supply of Industry 4.0 solutions too. In order to do so, machinery and equipment manufacturers will have to combine traditional and new ICT high-tech strategies. Hence, ICT-based technologies will have to be adapted for the specific requirements of industrial production. Accordingly, priority areas for action are identified in:

1. The standardisation of relevant architectures: Industry 4.0 aims at connecting value chains which include companies characterised by different business models. These architectures include: a) structural principles, interfaces and data, to integrate production and logistics; b) devices (automation, devices at the service of production departments, programmable logic controllers, operational devices, mobile devices, servers, workstations, etc.); c) software (sensors for data collection, sequence control systems, continuous process control systems, record-keeping, operations and business planning and optimisation, interfaces, integration with manufacturing); d) engineering development (PLM: product-life management); e) complexity management systems: planning models, making value added creation transparent (engineering skills), and explanatory models, which describes existing systems in order to gain knowledge (for instance, simulations analyses);
2. Implementation of ultra-wideband infrastructures, to ensure the functioning of CPSs, which requires fast and high quality data streams;
3. Health protection and safety to prevent Industria 4.0 technologies from damaging or endangering people and the environment, and to avoid unauthorised access to products and technologies;
4. Planning and organising labour to adequately meet the necessities of digitalised manufacturing: contents, processes and working environments will dramatically change, with repercussions on flexibility, working time, demography and privacy. For this reason, an innovative social organisation of workplaces will be necessary;
5. Vocational training and development of professional skills, since Industry 4.0 will radically change job profiles;
6. Regulatory framework for new technologies (criteria to ensure accordance with the law which, in its turn, will have to make innovation easier);
7. Resource efficiency.

With the Industry 4.0 Document [European Parliament, 2016], ITRE Committee provided the European Parliament (Directorate General for Internal Policies) with a general framework to interpet the phenomenon. According to this document, the term Industry 4.0 describes the organisation of production processes based on technologies and devices autonomously communicating with each other (through PCs or virtual models) along the whole value chain. The new model of 'smart factory' of the future includes computer driven systems monitoring production processes, creating virtual representations of the real world, making decisions decentralisation possible through self-adjustment systems. These concepts take into account that, within manufactures, physical objects become more and more integrated to information and communication networks. There will be three kinds of integration: 1) vertical integration, i.e. within a single plant/company, where the different functions are closely integrated; 2) horizontal, connecting geographically dispersed production networks to manage them in real time; 3) product integration, where the separation between manufacture and services becomes less relevant, since digital technologies make industrial productions and services to converge into 'hybrid' products, which are not mere physical goods but embed services. The terms Internet of Things (IoT) and Internet of Services also provide a useful description of digital integration of manufacture and services. Industry 4.0 can be thought of as the application of IoT to industrial and tertiary production: a multinational company such as

General Electric talks about Industrial Internet to stress how industrial and internet revolutions go hand-in-hand. The so called 'fourth industrial revolution' aims at connecting smart factories along the whole production chain, and at taking advantage of new generation automation developed since 2010. In this way, the different elements of the production chains, which previously were isolated, can be connected through RFID (Radio Frequency Identification), chips or minitrasponders. This also means that each and every component can embed digital information which can be shared via radio signals any time it moves along the production line; these products/objects, moreover, can communicate with each other independently of human acticity. Information generated in this way can be collected and analysed with big data and cloud technologies. The increasing digitalisation of manufacture will lead to the emergence of new production organisation and business models. In particular, the increasing utilisation of more and more sophisticated ICT technologies is blurring the boundaries between real and virtual world, leading to the emergence of CPSs, which Deloitte describes as online networks organised in a manner similar to social networks. Within CPSs, mechanical and electronical components are connected and communicate with each other via ICT tecnologies such as RFID or Ipv6 internet protocols, where each device has its own IP address. In this way, smart systems can share information about stock levels, problems and flaws, variations in demand, and hence can play a key role in coordinating processes to improve efficiency. According to the above mentioned document by Forschung-Acatech, companies aim at improving just-in-time maintenance of machinery; reducing down-times; customising production (also with the aid of 3D printing); implementing machinery self-adjustment and self-optimisation; digital integration (engineering) of the whole value chain; vertical integration and networking of manufacturing systems. Moreover, production can smoothly move along the whole production chain thanks to the fact that machines and cmponents can communicate the completion of each single step. The impacts of Industry 4.0 on different countries will be extremely heterogeneous, according to the characteristics of the corresponding industrial systems. Taking the case of Germany and Italy, i.e. the two most industrialised EU countries, Germany could obtain competitive advantages thanks to Industry 4.0 by implementing appropriate policies; while in the case of Italy, the final outcome is ambiguous given the great number of small and micro enterprises. According to the above mentioned document by the European Parliament, Industry 4.0 is expected to generate productivity growth through efficiency gains, for instance thanks to just-in-time maintenance and the reduction of downtimes. This should imply a reduction of unit costs, compensating higher labour costs with respect to emerging countries. From the point of view of policies to be implemented to reach these goals, the document recalls a paper by ECIPE (European Centre for International Political Economy), which considers vertical policies unsuccessful, and rather suggests horizontal policies, which promote competition and coordinate the interests of the different actors (private companies, governments, Trade Unions, etc.). In the US, the transition to Industry 4.0 was mainly driven by the private sector, and specifically by the Industrial Internet Consortium (IIC), made by companies such as General Electric, Cisco, Intel and IBM. This approach is radically different from the one adopted in Europe, where flagship initiatives were mainly driven by governments: in Germany (with the above mentioned project Industrie 4.0), Italy (where the government presented, on September 21, 2016, its own plan of incentives), and France (with the project Industrie du futur).

1.4 INDUSTRY 4.0 TECHNOLOGIES

A report by Boston Consulting Group [Boston Consulting Group, 2015a] lists st least nine Industry 4.0 technologies:

1. Big Data and Analytics. Analytics based on large data sets has emerged only recently in the manufacturing world, where it optimizes production quality, saves energy, and improves equipment service. The collection and comprehensive evaluation of data from many different sources (for example: production equipments, enterprises, customers) will become standard to support real-time decision making.
2. Autonomous Robots: this Robots are more autonomous, flexible, and cooperative; they can interact with one another and work safely side by side with humans and learn from them; moreover they have a greater range of capabilities than those used in manufacturing today.
3. Simulation: In the engineering phase, 3-D simulations of products, materials, and production processes will be used more extensively in plant operations as well; in this way it can mirror the physical world in a virtual model, including machines, products, and humans. This allows operators to test and optimize the machine settings for the next product in line in the virtual world before the physical changeover (thereby involving the change of production conditions).
4. Horizontal and Vertical System Integration: Today companies, suppliers, and customers are rarely closely linked; the same thing concerns the departments of the same undertaking, such as engineering, production, and service. Functions from the enterprise to the shop floor level are not fully integrated. But with Industry 4.0, companies, departments, functions, and capabilities will become much more cohesive, as cross-company, universal data-integration networks evolve and enable truly automated value chains.
5. The Industrial Internet of Things: A great many devices – sometimes including even unfinished products – will be enriched with embedded computing and connected using standard technologies. This allows field devices (spread across the production chain as a whole) to communicate and interact both with one another and with more centralized controllers; it also decentralizes analytics and decision making, enabling real-time responses.
6. Cybersecurity: With the increased connectivity and use of standard communications protocols that come with Industry 4.0, the need to protect critical industrial systems, manufacturing lines and Data collected increases dramatically.
7. Cloud: With Industry 4.0, more production-related undertakings will require increased data sharing across sites and company boundaries; at the same time, the performance of cloud technologies will improve, achieving reaction times of just several milliseconds. Even systems that monitor and control processes may become cloud based.
8. Additive Manufacturing: With 3D printing the companies will be able to realise more rapidly prototypes and individual components, but also small batches of customized products; 3D printing can be decentralized reducing transport distances and stock on hand.
9. Augmented reality: These systems support a variety of services, such as selecting parts in a warehouse and sending repair instructions over mobile devices. These systems – often embedded in wearable devices - can provide workers with real-time information to improve

decision making and work procedures. This information may be displayed directly in workers' field of sight using devices such as augmented-reality glasses. Another application is virtual training.

1.5 PRODUCTION NETWORKS, SUPPLY CHAINS AND INDUSTRY 4.0

The topic of supply chains, both at the local and at the global level, is very important within literature about Industry 4.0, since they will likely be strongly affected by these technologies. The above mentioned report by Boston Consulting Group stresses, among the nine Industry 4.0 technology, the relevance of those under item 4), i.e. horizontal and vertical integration systems. According to the report, "Many of the nine advances in technology that form the foundation for Industry 4.0 are already used in manufacturing, but with Industry 4.0, they will transform production: isolated, optimized cells will come together as a fully integrated, automated, and optimized production flow, leading to greater efficiencies and changing traditional production relationships among suppliers, producers, and customers—aswell as between human and machine" [Boston Consulting Group, 2015a, p.4]. A research conducted by PWC [2015] stressed that industrial internet entirely transforms companies: in five years, the 80% of companies will have a totally digitalised value chain; industrial internet will improve productivity and efficiency in the use of resources, and will pave the way to new, disruptive business models based on digital technologies, while horizontal cooperation will improve the capacity of meeting customers' needs and requirements. Another report by Boston Consulting Group [2015b] selects ten applications of Industry 4.0 on the basis of their overall impact on the labour force: among them, we find production lines simulations and smart supply chains. As regards smart supply chains, BCG stresses that "By using technology to monitor its entire supply network, an international consumer-goods company has enabled better supply decisions. This application of technology will reduce the number of jobs in operations planning, while creating demand for supply chain coordinators to handle deliveries in smaller lot sizes" [Boston Consulting Group, 2015b, p.6].

Roland Berger [2014], talking about the fully connected way of making things, stresses that; "Industry 4.0 is based on new and radically changed processes in manufacturing companies: Factory 4.0. In this concept, data is gathered from suppliers, customers and the company itself and evaluated before being linked up with real production. The latter is increasingly using new technologies such as sensors, 3D printing and next-generation robots. The result: production processes are fine-tuned, adjusted or set up differently in real time" [Roland Berger, 2014, p.10].

Roland Berger [2016] devoted another report to the US automotive production chain. In this sector, "increasingly integrated supply chains and highly automated intra-plant logistics are expected to bring steady improvements to logistics efficiency in the coming years. These overall changes will be driven by technologies such as smart storage (enabling optimized internal logistics planning) and demand driven provision of materials and goods. [...] This is highly relevant for digital factories and U.S. competitiveness as software capable of linking manufacturing equipment with the internet and integrating supply chains remains a crucial missing element. [...] The introduction of Toyota's production system and just-in-time manufacturing turbocharged the necessity of supply chain integration in automotive. Witnessing Toyota's success in improving product quality while lowering working capital, rival OEMs quickly adopted similar manufacturing policies and techniques. BMW, when moving serial production to the United States, insisted that suppliers also bring manufacturing capabilities to support the entire supply chain. This sequence of continuously improving production and supplier integration in the U.S. has created an environment prepared for further supply chain integration – thus setting the stage for the benefits of manufacturing digitization" [Roland Berger, 2016, p.12].

Digital factories will have a strong impact on the management of production and supply chains. It is clear, however, that this has strong impacts on labour, as recognised by another report by Roland Berger, because Industry 4.0 technology will also ensure a reduction of labour costs, and an increase in capacity utilisation rates. Moreover, according to the European Parliament [2016]: "Industry 4.0 describes the organisation of production processes based on technology and devices autonomously communicating with each other along the value chain: a model of the 'smart' factory of the future where computer-driven systems monitor physical processes, create a virtual copy of the physical world and make decentralised decisions based on self-organisation mechanisms. The concept takes account of the increased digitalisation of manufacturing industries where physical objects are seamlessly integrated into the information network, allowing for decentralised production and real-time adaptation in the future" [European Parliament, 2016, p.9]. The main Industry 4.0 technologies are also strongly linked to the concept of value chain: 1) IoT concerns ICT systems connected to all subsystems, processes, internal and external objects, supply and sales networks; all these nodes of the network communicate both with each other and with human beings; 2) Internet of Services concerns internal services and services supplied to all participants to the value chain, driven by big data and cloud computing. 3) digital integration and engineering of the whole value chain goes from design to internal logistics, marketing, external logistics, and post-sales services. The goal is that of shaping and expanding German market shares through the networking of close companies and their cooperation. This will require the digital integration of the different stages of value chains, product life cycles and manufacturing systems. Talking about Germany, the report stresses that "Industrie 4.0 holds huge potential for manufacturing industry in Germany. ... The leading market for Industrie 4.0 is Germany's domestic manufacturing industry." [European Parliament, 2016, p.29]. The above mentioned report by ITRE also dwells on the role SMEs, which are to a large extent integrated into complex supply chains of big (often multinational) enterprises; other SMEs supply local and regional networks. Due to this interdependence of SMEs on big manufacturing companies, they also have to adopt advanced technologies and working methods. They will have to adapt to new standards and methods in use in the corresponding sectors, in order to be able to remain competitive and preserve their linkages to the existing chains. Industry 4.0 can make production internationalisation more important than ever – which will be easier for big business than for SMEs, which in their turn might see an increase of their dependence on the former. It is therefore clear that Industry 4.0 will play a key role in connecting production chains both at the local and at the global level.

1.6 DIGITALISATION AND EMPLOYMENT

In what follows, we are going to briefly summarise a review [Freddi, 2017] of the literature on the relationship between digitalisation and unemployment. New digital technologies can be disruptive in many ways, since they offer radically new ways of producing, purchasing, selling and organising, with relevant consequences on employment levels and, in general, on the functioning of economic systems.

According to several authors [Brynjolfsson and McAfee, 2014; Rifkin, 2014], the current technological change offer some radical new opportunities that can lead to significant transformations not only in the way of producing and doing business but also in the overall economic system. In particular there is an increasing interest towards the impact of some specific technologies such as robots, the internet of things, the additive manufacturing, augmented reality, big data and analytics. Among the others, the use of robots and their actual ability at substituting for human labour attracted most of the attention of literature contributions. The reason for that is that contemporary robots show the ability to substitute for labour not only in the low-skilled repetitive tasks but also in more complex high-skill occupations (for recent wide overview of robots and in particular on their use in social applications, see Royakkers and van Est [2016]). The ability of these robots is documented in particular by the case of the supercomputer Watson, developed by IBM, which competed and won against two humans in a famous American TV game show [Brynjolfsson and McAfee, 2014]. This episode demonstrated two relevant elements related to the cognitive ability of robots. On the one hand it showed that robots could do well in two abilities that according to Levy and Murnane [2004] only humans could succeed: "pattern recognition" and "complex communication". In line with the observation of Polanyi [1966] that, as humans, "we know more than we can tell", Levy and Murnane suggested that computers could not fully replace human labour as computers are good at following rules but not at recognising a pattern. So, for example these authors point out that: "as the driver makes his left turn against traffic, he confronts a wall of images and sounds generated by oncoming cars, traffic lights, store fronts, billboards, trees, and a traffic policeman. Using knowledge, he must estimate the size and position of each of these objects and the likelihood that they pose a hazard [. . .] the truck drivers [has] the schema to recognize what [he is] confronting. But articulating this knowledge and embedding it in software for all but highly structured situations are at present enormously difficult task" [Levy and Murnane, 2004, p.28]. Moreover the same authors suggest that computers could not substitute for humans in complex communication: "Conversation critical to effective teaching, managing, selling, and many other occupations require the transfer and interpretation of a broad range of information. In these cases, the possibility of exchanging the information with a computer, rather than another human, is a long way off." [Levy and Murnane, 2004, p.29].

According to Brynjolfsson and McAfee [2014], the case of Watson showed not only that computers could both dealing with pattern recognition and complex communication but also that they are very quick learners, as Watson did not win at the first tentative in 2006 but at the second one, four years later. Other authors questioned the actual possibility to fully overcome the Polany's paradox, sustaining that currently this has not happened yet as there are tasks that have proved to be very difficult to automate, in particular those involving "flexibility, judgement and common sense." [Autor, 2015, p.22]. According to this contribution, there may be "two distinct paths that engineering and computer science can seek to traverse to automate tasks for which we 'do not know the rules': environmental control and machine learning." In relation to environmental control, by means of the case of the Google self-driving car, often pointed as one of the best example of the most sophisticated possibility to substitute for human skills, Autor [2015, p.24] underlines that Google cars do not drive on roads but actually on maps: "a Google car navigates through the road network primarily by comparing its real-time audiovisual sensor data against painstakingly hand-curated maps that specify the exact locations of all roads, signals, signage, and obstacles. The Google car adapts in real time to obstacles, such as cars, pedestrians, and road hazards, by braking, turning, and stopping. But if the car's software determines that the environment in which it is operating differs from the environment that has been pre-processed by its human engineers—when it encounters an unexpected detour or a crossing guard instead of a traffic signal—the car requires its human operator to take control. [. . .] These examples highlight both the limitations of current technology to accomplish non-routine tasks, and the capacity of human ingenuity to surmount some of these obstacles by re-engineering the environment in which work tasks are performed." Secondly, machine learning could overcome the problem that engineers are unable to program a machine to "simulate" non-routine tasks following a script procedure. In case computers are required to identify a chair, "relying on large databases of so-called "ground truth"—a vast set of curated examples of labelled objects—a machine learning algorithm attempts to infer what attributes of an object make it more or less likely to be designated a chair." [Autor, 2015, p.25].

However, according to the author, these tools, do not perform very well and if the famous computer Watson won in the TV show game, it is also true that it made also significant mistakes. Even if, according to Andreopoulos and Tsotsos [2013] these products should still be considered as prototypes as the underpinning technologies are all improving quickly, in Autor's view, when a person is required to identify a chair do so by knowing that the observed object is used to sit on. Therefore humans make use of the concept of "purposiveness", which is very difficult to automate and also difficult to be substituted by the recording of a large number of images. Finally, we would like to recall one last controversial issue related to computers' abilities and the possibility for human labour substitution. While at the end of the 80s the cognitive abilities of computers were expanding thus opening up the possibility of substituting high skilled tasks the roboticist Moravec [1988, p.15] pointed out that it was "comparatively easy to make computers exhibit adult-level performance on intelligence tests or playing checkers, and difficult or impossible to give them the skills of a one-year-old when it come to perception and mobility." This point, later known as the Moravec paradox, was coherent with the cognitive scientist Pinker [2007, pp.190-191] when he suggested that "the main lesson of the thirty-five years of Artificial Intelligence research is that the hard problems are easy and the easy problems are hard [. . .]. As the new generation of intelligence devices appears, it will be the stock analyst and petrochemical engineers and parole board members who are in danger of being replaced by machines. The gardeners, receptionists, and cooks are secure in their jobs for decades to come." Even if currently there is no clear evidence that the so called Moravec paradox has been overcome, according to Brynjolfsson and McAfee [2014, p.31], the collaborative robots Baxter, produced by Rethink Robotics, "are not as fast or fluid as a well-trained human worker at full speed, but they might not need to be" while have several advantages over human workers as "can work all day every day without needing sleep, lunch, or coffee breaks."

The existence of a direct link between innovation and productivity has been put into question by Solow [1987]: "[Y]ou can see computer age everywhere but in the productivity statistics." This well known paper was not Solow's first drive into the issue of the link between technological innovation and productivity changes. In this respect, it is worth recalling the 1956-57 debate between Solow and Pasinetti. In a well known article, Solow [1957] analysed the performance of US over the period 1909-1949, concluding that output per hour doubled. According to his computations, the 12.5% of such an increase was due to the growth of the capital/labour ratio, i.e. to a higher per-capita endowment of fixed capital – or, to borrow Pasinetti's terminology, to a higher degree of mechanisation – while the 87.5% was due to technical change. It is the well known 'Solow's residual', which takes its name from the fact that it is caused by movements of the production function – i.e. by the possibility of producing a greater quantity of output given the same quantity of inputs – rather than along the production function – i.e. changes in the relative quantities of capital and labour employed in the production process. Solow generically considers movements of the production function as being caused by technical progess.

Solow therefore concluded that, over the period considered, technical progress had been mainly neutral in the sense of Hicks, i.e. increased the quantity of output which can be produced from given inputs, without changing marginal rates of substitution. In his reply to Solow's paper, Pasinetti [1959] stressed that Solow's analysis neglected a fundamental characteristic of fixed and circulating capital: reproducibility, which is also subject to technical change. In order to draw conclusions about the direction of technical change, therefore, Pasinetti considered not only the process of production of the final good, but also that of the corresponding productive capacity, i.e. of all capital, both fixed and circulating, necessary in each sector of the economic system to make goods and services available for final consumption. The unit of analisys, therefore, is not only the industry producing final commodities, but rather the whole subsystem – or production chain – consisting of all industries directly and indirectly providing intermediate inputs. Starting from here, Pasinetti derives an index of the direction of technical change taking into account technical change in the production of capital as well. This index is given by the ratio of the quantity of direct labour necessary for the production of the final commodity to the quantity of labour which would be necessary for the reproduction, with the technique currently in use, of productive capacity available to the whole subsystem. Changes through time of this index reflect the presence of technical progress, which can be labour-saving or capital-saving – i.e. making it possible to produce the same output with a smaller quantity of labour or capital, respectively. Since capital is also produced, however, and since its production requires labour, technical progress is ultimately always labour saving. This debate makes it clear that Solow and Pasinetti had in mind two different definition of the concept of productivity, due to their different theoretical backgrounds. In the neoclassical paradigm, factors productivity is defined as their marginal productivity, i.e. the additional quantity of output that can be obtained by employing an additional unit of the corresponding factor of production. Analytically, we are talking about the first derivatives of the production function with respect to capital and labour, which correspond to their equilibrium remuneration. The concept is therefore strictly connected to that of production function, with all its well known theoretical drawbacks. On the contrary, Pasinetti defines productivity as labour productivity only –

since capital is produced and employed by labour – and in strictly physical terms, as the number of hours necessary in the economic system as a whole to produce a unit of the various goods and services for final consumption. In other words, the concept of productivity is not only physical, but also systemic and sectoral. Systemic because it does not involve the industry producing the final good only; sectoral because productivity grows at different rates in the different subsystems. The latter point is extremely important because, even in the absence of relevant technical changes, overall productivity can change simply due to a change in the composition of final output.

1.7 HINTS TO THE ITALIAN SITUATION

The Government's Plan "Industry 4.0"

The Italian Government in the 2015 gave its opinion, in the person of the Minister of Economic Development, Carlo Calenda, during a parliamentary hearing at the Chamber of Deputies. According to the Minister, digitalisation will improve the competitiveness of the Italian manufacturing sector, starting from those production chains mainly based on SMEs. The first industrial sectors to be affected by Industry 4.0 will be machinery, industrial automation, components (especially automotive), aeronautics, shipbuilding, electronics, electrical machinery and logistics; however, in the future more traditional sectors – such as health, agriculture, transports, etc. – will be touched upon as well.

The Minister stressed some peculiar aspects of the Italian industrial structure which make it particularly subject to being affected by Industry 4.0. Especially in the sectors producing machines for industrial automation and components (mechanics and mechatronics), SMEs are clustered in industrial districts which would become more and more integrated with a reduction of the distance, within the value chains, between suppliers and subcontractors.

The Minister ruled out the possibility that Italian industrial policies will foster the development of vertical chains, instead giving priority to a horizontal approach based on innovation, internationalisation and recourse to the capital market.

The Government's plan includes five intervention areas. The first one is intended to provide for investment in innovation and legal incentives (laws for machinery modernisation, patent box, tax credits on R&D, etc.) to close the gap 8 billion euros. The second concerns investments in technologies (connectivity infrastructure, reduction of SMEs' digital divide, improvement of STEM skills). The third area concerns interoperability and communication standards in order to foster production processes and business models based on IoT. The fourth aims at developing corporate finance in order to support companies' investments for Industry 4.0.

Finally, from the point of view of labour organisation, the Minister endorsed the need for making industrial relations more flexible by decentralising bargaining activities to the level of the single firms and closely linking salary adjustments and corporate productivity according to a model which, in recent years, has been strongly supported by the latest governments and CONFINDUSTRIA (the General Confederation of Italian Industry).

In March 2016, the Italian Government introduced a draft bill where smart working is defined as meeting three characteristics: a) the working activity takes place both inside and outside the firm's premises, within the bounds of daily and weekly working hours; b) the worker might make use of technological tools; and c) tasks performed outside the premises do not take place in a specific work station. The most worrying aspect of this draft bill concerns the lack of reference to the kind of national collective working agreement to be applied to these workers; reference is only made to generic, almost ambiguous statements that the smart worker is entitled to emoluments that are overall equivalent to those granted to 'standard' workers. However, the meaning of the term 'overall' is not at all clear.

The Government's plan

This plan has been presented in September 2016.

First of all, the entirety of the Plan's objectives concern only the firm-level: greater flexibility, which would allow to take advantage of economies of scale even when producing small batches; shortening the time necessary for prototypes to be switched-over to series production; decreasing set-up time, mistakes and machines stops, which would enhance productivity; the introduction of sensors monitoring production in real time, which would increase quality. Everything, of course, in conformity with the imperative of competitiveness, to be achieved thanks to the advantages offered by internet.

The specific measures included in the Plan entail a substantial commitment of public resources to private enterprises: in relation to investments in innovation, the Government aims to leverage 24 billion euro of private investments by making 13 billion euro available, from 2017 to 2020, to pay for amortisation, super-amortisation and hyper-amortisation on investments in technology and capital goods; to finance the "Fondo Rotativo Imprese", which provides firms with credit to lower rates to firms making investments in innovation; to finance tax credit for private research; to strengthen the financial system supporting Industry 4.0.

To make a single example, thanks to hyper-amortisation, a firm making a 1 million euro investment in capital goods imputable to Industry 4.0 would get an enormous tax break, getting a 360000 – instead of 96000 - tax benefit over five years, with the tax benefit increasing by 275%.

In the field of skills development, the public commitment amounts to 700 million euro, as against 200 millions from the private sector.

Finally, the public commitment to the main support measures amounts to 10 billion euro in 4 years, as against 32 billion of private money; it is worth to see what these are about.

A significant part is devoted to the realisation of ultra-broadband, the associated investment being for more than a half (6.7 billion euro) financed by the State.

There is of course a chapter devoted to "salary-productivity exchange", with the State funding firm-level bargaining aimed at linking wage increases to productivity changes with 1.3 billion euro.

To conclude, the class aspect of these measures is apparent: billions euro provided to firms in any possible way, and absolutely no occupational, social, and even less industrial target.

The weaknesses of the Plan

First, the infrastructure provision plan is already showing the first criticality: the realisation of ultra-broadband is extremely behind schedule.

Secondly, public commitment should stimulate private investments in goods and technologies connected to Industry 4.0. However it is not clear whether such investments would generate production and employment in Italy or abroad. In other words, are sensors, devices, robots, hardware, software and so on going to be produced in Italy or imported? If the latter is the case, besides a worsening of Italian trade balance, the Government's plan is going to generate employment abroad rather than in Italy.

Morevoer, the Plan hardly mentions a chronic weakness of the Italian industrial system, i.e. the absolute predominance of small enterprises, usually part of more complex production chains whose head is located abroad, often in Germany. The risk is therefore that of digitalising a set of production chains led by German companies, whose leadership on the whole supply-chain would be even reinforced.

Finally the Plan, by its own admission, adopts a horizontal approach to industrial policies, with the explicitly stated aim of avoiding the vertical approach.

The great absentee: Labour

The Plan lacks any reference to labour, but in terms of training and skills development.

One example will suffice: Industry 4.0 will generate new jobs (new sectors, products, services) and, at the same time, will destroy jobs (due to automation, robots, etc.). Estimating job balance at the single firm or sector level appears to be feasible. Moreover, it would be worth trying to understand the way in which Industry 4.0 will change workers' status (new and more flexible forms of employment; dichotomy between employment and self-employment, etc) and working conditions (working time, safety at work, etc.).

How will companies and territories comply with the new paradigm? Which new skills will become necessary? How will working tasks and processes change? How will working performance take place, and be monitored by each firm? All these are questions which the Government's Plan does not even mention. As usual, the only point of view adopted is the enterprises' one.

CHAPTER 2

Field research: a sample of Italian companies

2.1 AN ANALYTICAL FRAMEWORK FOR CROSS READING THE CASE STUDIES: UNDERSTANDING THE RATIONALE OF THE PROCESS OF CHANGE

The coevolution paradigm

In the literature on technological innovation processes, the concept of co-evolution "of technological, business and industrial structures and social and public institutions which support them, connected by complex feedback processes." [Jacobs and Mazzucato, 2016, p. 20]; or, following Perez [2016, p. 194]: "The result is what can be described as a " techno-economic paradigm shift", which leads to a profound transformation in ways of working and consuming, changing lifestyles and aspirations across society"

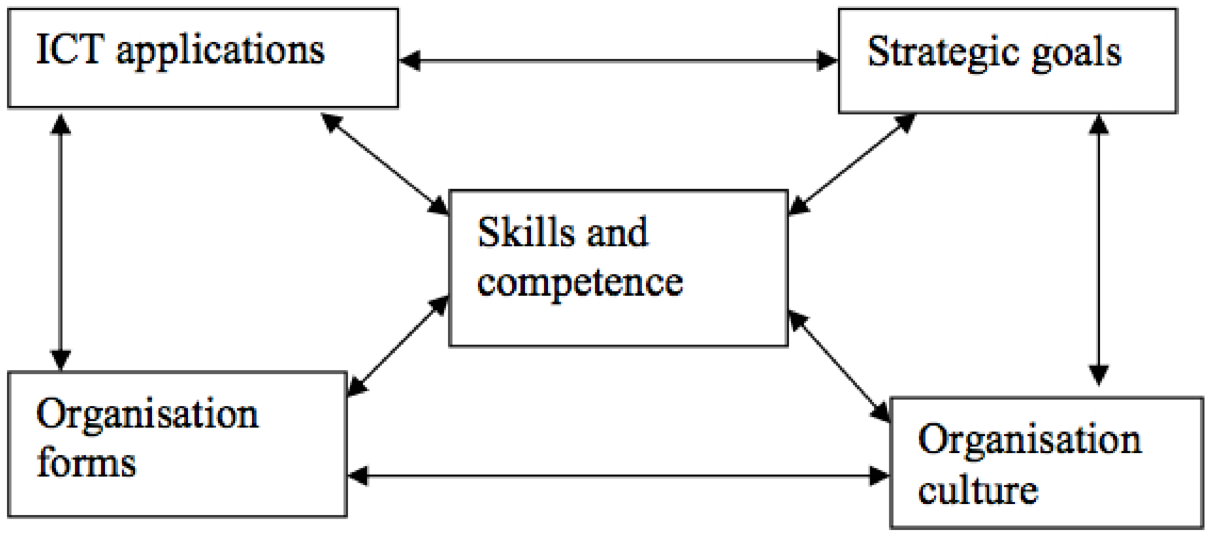
Looking at the relationships between technological and organizational innovation Brynjolfsson and McAfee [2014, pp. 1783-1787] point out that, "[f]or example, when companies spend millions of dollars on hardware and software for a new corporate resource planning system, they also include process changes that are three or five times more expensive than original hardware and software investments."

Murmann [2013] has formalised co-evolution patterns between companies and their environment that has been used in various field research; see, e.g. Freddi and Rizzo [2016].

More generally Schienstock [2002], in the final report of the SOWING project, states that:

> Instead of assuming that ICT applications are the strategic goals of companies, we are interpreting the relationship between technical artefacts and business objectives as a process of co-evolution. Modern ICT applications, organisational forms, cultural models and strategic business goals or the implementation criteria, in our view, co-evolve in the development of the information economy by mutually affecting each other. It seems obvious that only a more holistic approach, given the interdependent nature of these dimensions, can maximise the synergies to be obtained from a fundamental process of

Figure 2.1: Technological practice [Schienstock, 2002, p. 28]



> transformation (Murray and Willmott 1999:167). The analysis of the information economy implies the application of this holistic approach. [Schienstock, 2002, p. 26]

And yet:

> In analysing technology practices, we need to highlight a cluster of complementary variables that go along with the technology in use. In addition to the applications of modern ICTs, as we have already stated, technological practices also include organisational forms, strategic business objectives and specific cultural models. Given that the elements of technological practices are closely linked and mutually affect one another, we can talk about a process of co-evolution. [Schienstock, 2002, p. 28]

The diagram in Figure 2.1 highlights the analytic nodes and their relationships.

As it was then, it is now obvious that "[t]echnological practices not only require specific skills and competencies as well as produce social exclusion risks for specific groups of workers." [Schienstock, 2002, p. 31]

The technology practices approach has been used in many field research activities over the past fifteen years. We intend to use it to analyse our case studies that we have articulated by industrial sectors, for instance:

- *Machinery and equipment for industry and trade:*
  IMA, Cesab-Toyota, Cefla, Costan, Sacmi, Kosme
- *Parts and electromechanical components*
  Carel, Bonfiglioli, Midac, ABB Bergamo, Magneti Marelli Milan, STM Milan
- *Consumer Products*
  Ducati, Lamborghini

We will analyse each of the five analytic nodes of Figure 2.1 and try to extract some typical models of technology practices that we will use to classify the whole case studies. The analytic scheme we will use is that of Table 2.1.

In order to analyse the employees' interviews, we utilised the following list of issues:

- Occupational impact
- Skills, competencies
- Production cadences, working times, saturation
- Short description of the lean production model and organisation or of other production models
- scope and modalities of control on employees' performances
- Scope and modalities of technology-driven work activities
- Networks (main suppliers, other Group companies, customers - the latter can be another companies producing intermediate goods/services, not necessarily end-users)
- Industrial Relations
- Company agreements and bargaining activities (i.e. what are the topics for this field)

2.2 LIST OF THE COMPANIES, FROM WEST TO EAST AND FROM NORTH TO SOUTH

Piemonte

COMAU – Grugliasco (TO)
Fiat Power Train – Torino

Lombardia

ABB Italia
ABB – Dalmine (BG)
Alstom – Sesto San Giovanni (MI)
ST Microelectronics (STM) – Agrate and Castelletto (MI)
Magneti Marelli – Corbetta (MI)
General Electric – Talamona (SO)
Kosme – Roverbella (MN)

Veneto

CAREL – Brugine (PD)
COSTAN – Belluno
MIDAC – Soave Veronese (VR)
Fonderie Zanardi – Minerbe (VR)

Table 2.1: Analytical Dimensions

Analytical dimensions	Type 1	Type i	Type n
1. Industry 4.0 Support Technologies. Mode of use: full, selective, minimal			
2. Fields of application: product/process			
3. Objective of the product field: list the first three			
4. Process field goals: list the top three			
5. Restructuring processes to support the implementation of the technologies: no, intense, moderate, minimal			
6. Business functions involved in the restructuring process: smart execution, smart planning, smart integration*			
7. Prevalent organisational culture: centralised, decentralised			
8. Supply chain involvement: no, intense, moderate, minimal			
9. Corporate strategic goals: list the top three			
10. Time horizon			
11. Factors hindering the project: list the top three			
12. Discrimination risks: no, yes and they involve (...)			
13. Involvement of users: no, yes			
14. In the form of: information, participation in goal setting, participatory design			
15. Trade Unions involvement: no, yes			
16. At what level: Union leaders, delegates, workers directly involved, everyone			
17. Occupational risks: no, high, medium, low			

* A. Smart Execution, Manufacturing Operational Processes: Production, Logistics, Maintenance, Quality and Safety Criteria Satisfaction

B. Smart Planning: planning of production and distribution, inventory management and dynamic supply chain management

C. Smart Integration, Related Processes: new product development, relationship management with product life-cycle management

Emilia Romagna

Ducati Motor – Bologna
IMA – Ozzano (BO)
Lamborghini Manufacturing – Sant'Agata Bolognese (BO)
Bonfiglioli Group - Lippo di Calderara Di Reno (BO)
Toyota Motor Handling Manufacturig – former known as CESAB- Bologna
Cefla – Imola (Bo)
SACMI – Imola (BO)
Comer – Reggiolo (RE)
Carpenfer – Reggiolo (RE)
Interpump – Calerno – Sant'Ilario d'Enza (RE)
Graniti Fiandre – Casalgrande (RE)

Puglia

Bosch – Modugno (BA)

Reports differ on the extent of the issues afforded, on the analytical depth reached in each subject and, in some cases, on the absence either of the management or the employees' interviews. These differences are due to different availability of informed people and on the degree of personal information of the interviewed persons.

2.3 DUCATI MOTOR

Ducati is owned by German automotive manufacturer Audi through its Italian subsidiary Lamborghini, which is all owned by the Volkswagen Group. In 2016, Ducati sold 55.000 motorbikes, had 1594 employees and a 731 million euro revenue.

Interviews with managers

The long-lasting strategic problem in organisational terms is the shift from batch production to custom-made production; production volumes vary widely during the year according to seasonal cycles - from 140 to 410 bikes/day.

Hence, there are two requirements of flexibility: (i) processing different motors by inserting them randomly on the production line; (ii) Adjusting the production done and to-be-done in real time.

In organisational terms, it means a very tense flow, allowing for:

1. elimination of micro-phases; the operator fully assembles the engine with a fixed-base technological sequence upon which the variants are added to a defined number, can then process different motors in random sequences;
2. a kanban based on fixed frequencies - 4 hours - and variable volumes;
3. A so-called in-house supermarket - with the same 4 hours autonomy - with all that is needed for that assembly cycle. It is articulated into different sub-supermarkets for each basic model.

Digitisation comes in handy: all tools are digitised and communicate with a *virtual supervisor* who guides the operator in the different phases depending on the model; the supermarket pulsates synchronously with the production by getting tools and parts just-in-time. All this is based on SAP that "does everything", and on a logic of inter-functional teams.

The technologies in use in the process (smart factory) are:

- *Tool and parts lighting* on when should be picked up by the operator. It is not so simple, you need a perfect set up of SAP.
- *Virtual configurators*. They are utilising it for selecting the parts on the assembly lines.
- *3D Printing*. Utilised for tooling. The process up till now utilises resins; they know that AUDI is utilizing also process of sintering but it is a very costly process not suitable for mass production.
- *Immersive and augmented reality* technologies are under examination but they have not yet decided what to do.
- *AGVs* will be introduced during this year.
- *Paperless factory*. They have made good progress; their final objective is to do as Audi does, that is the full elimination of the physical file of each motorcycle.
- *Collaborative Robots*. They are planning for a small robot. They bought a Universal robot and they asked to a local software-house to develop the software they need.
- *Big Data analytics*. They should analyse the data coming from digital tools: digital screwers and torque wrenches

Parallely, the technologies in use in the products (smart products) are:

- *Wireless connection* of the motorcycle with the driver jacket activating the airbag in case of an accident.
- *Vehicle-to-vehicle digital communication* advising the car driver of an incoming motorcycle.

The company therefore needs a mix of professional profiles: engineers and technical experts. The ideal solution is that engineers also have a mechanical training.

The level of technical schools is now low. The company organises internships in collaboration with both universities, continuously, and technical institutes, in a less structured manner.

The hegemony of *Silicon Valley* firms on ICT is a problem. The strategy they are using is to utilise the might of the Emilian *Motor Valley* to form strategic alliances with those USA firms. They are trying this strategy. With the *frightful fives* (Facebook, Amazon, Netflix, Google and Microsoft) is very difficult, the only motor vehicle firm which succeeded in forming an alliance with Apple is Ferrari automotive.

Interviews with workers

We interviewed 19 workers with different skills and tasks employed in various departments of the company. More in detail, the distribution of workers in Ducati was structured in the following way: 2 testers, 1 machine tool operator, 1 assistant manager, 1 mechanic motorbike racing area, 1 employed in prototype department, 3 workers in the quality department, 6 assemblers, 1 engine area assemblers, 1 engine testing room worker, 1 engine industrialization employee, 1 team leader in Panigale assembly line.

Semi-structured interviews focused on five main topics:

1. Mobility of workers (career opportunities, displacement between departments, on the job training, contractual conditions, etc.)
2. Job rotation of workers among tasks
3. Workers' evaluation methods
4. Workers' participation (team working, suggestions...) methods
5. Description of the technological change experienced in the factory

In Ducati, workers have the possibility of job career. However, the modality of workers selection into career programs are seen as selective and discretional to the management decisions. Most workers do not know the requirements to pass from one level to the other in terms of knowledge, years of experience, multitasking, job rotation, qualification, etc. Therefore, they ignore the criteria to fulfil management expectations to have promotions and experience career opportunities. Most workers perceive job career opportunities in Ducati as very unfair, they admit that in Ducati it is possible to experience some forms of career, however they ignore the modalities to do it.

Furthermore, these opportunities are seen as far in time and insecure. Displacement between departments can occur both as a form of punishment or promotion according to the individual experience and job position.

Job training exists and it strictly linked to the task performed. It is generally a job training performed by other workers on the production line and it lasts on average one week. Most workers would like to experience more training and perceive that on the job training should be a work-life long training and not just sporadic or even rare.

Contractual conditions stating wage increases and tasks change across workers. Usually production workers are hired with a 3rd level and after few years have the opportunity to join a 4th level contract. However, the 4th level constitutes a "glass ceiling" for most of them due to the difficulty to go further, unless exceptional cases.

Job rotation is appreciated both by management and by workers judging it as a good opportunity to break a routinized work where in most of cases they only have to repeat standardized operations. Indeed, the perception varies according to the department and to the worker's qualification. All workers interviewed have experienced at least one form of job rotation in the same department going from one assembling line to the other, or changing position in the same assembling line. Although job rotation is welcome by the management, there is a lack of formalization of rotational schemes. Workers experience forms of job flexibility but they ignore the criteria for that and for the acknowledgment of "multifunctionality" which is indeed correlated to wage premia.

Workers' evaluation plans are applied in Ducati motor and they are strictly related to the granting of corporate awards, such as the so-called "zero defects prize". However, the criteria to access such awards are unclear and seem to be discretional to the middle management of the enterprise. Team leaders and supervisors - who intervene in the production process in case of need and have a role of problem-solver - evaluate workers continuously.

Workers' participation methods are present in Ducati and range a vast set of activities such as planning of team working or collecting suggestions or workers' evaluations concerning colleagues and supervisors' behavior. In some cases, meetings are weekly organized on the production lines to coordinate and plan production activities involving production workers on the assembly lines. However, team coordination meetings in most cases are rare – once each three months.

Furthermore, in the last years, a new process of evaluation and self-assessment has been put in place filling two times per year an anonymous questionnaire containing workers evaluation on pairs and supervisors. This practice has been introduced since Audi has come into the management of Ducati motor and it aims to detect workers perception on working conditions.

According to most workers, a valuable example of evaluation and improvement has been the GMK System, a dedicated method to valorize workers' suggestions and ideas on production process and working conditions. Overall, at the end of each line there is a board where workers can fill forms containing suggestions on production process. However, the latter is not commonly used.

Workers perception on the evolution of technological opportunities in Ducati strongly varies among workers. At a first look, it seems to be correlated to the position in the hierarchy of the factory and the task performed by the worker. Overall, the career opportunity of the worker influences her perception of technological change in the firm and mostly her view of Ducati dynamism in technology adoption and generation.

Most workers acknowledge an improvement of working conditions in terms of safety and ergonomics. Therefore, they consider as a full improvement the introduction of wrenches and wireless screwdrivers because they reduce the effort done by the shoulders. However, the adoption of new technologies along the lines has been perceived as not uniformly distributed in the firm. Some workers describe Ducati motor as characterized by dualism where two different typologies of factories coexist. The first one is a technological one where an increasing attention towards mechanical tools, digitalization processes, participative organizational methods are detected. This first factory has been described as a "shuttle" and includes the research center as well as administrative and managerial offices and the new Panigale assembly line. Then, there is a less modern one – including for example the Scrambler line – where Ducati has no longer invested money for new machinery. This part of the factory has been described as the "stone age" firm. According to some workers, even the way of the management of relating to workers is perceived as different, in one case more hierarchic, while in the other part of the firm it is quite informal, more inclusive and prone to stimulate participation.

2.4 IMA

IMA's business consists in the design and manufacture of automatic machines for the processing and packaging of many different products. Its ecosystem is made up of automatic machines for these sectors: Pharma; Personal Care; Food and Dairy; Tea, Coffee and Beverages; Confectionery and recently added Tobacco. Besides, IMA has a recently established business hub composed of leading companies in the automation industry, dedicated to offering its clients a wide range of technological solutions for assembling and demolding.

In 2017, IMA had 5.382 employees and a 654,6 million euro total revenue.

IMA Group owns different companies: IMA, with many sites; GIMA (100%) in the automation sector, GIMATT (60,8%) in the Tobacco sector, Corazza (100%) in the Food and Dairy sector.

IMA operates in these sectors: Pharma with the brands Active, Life and Safe; Tea & Herbs; BFB – end of line solutions: bundling & wrapping machines, case-packers, palletizers and de-palletizers.

IMA launched a project for 'Packaging 4.0' called IMA Digital, described on the company's website as reported in the following subsection

IMA DIGITAL: a project for PACKAGING 4.0

Introduced for the first time at INTERPACK 2017, IMA DIGITAL is the new company's comprehensive project to tackle the digitization challenge that is transforming the manufacturing world. Businesses face unprecedented disruption.

Smart Machines

According to IMA, the right path to reach higher standards in the machine's intelligence is the one which enables the experience and knowledge of the machine's manufacturer to be embedded into the machine itself.

The combination of machine unit sensors with the IMA knowledge of the machine functions in different production conditions will enable the possibility to get useful information regarding the machine status and life expectations, allowing prognosis services for fault research and predictive maintenance plans.

- HW architecture of data collection in parallel with the machine motion control
- Data collection of particularly important components in different working conditions
- Realization of analysis tools
- Sensors integration and analysis tools on IMA machines (Edge Computing)
- All the information coming from the machine must be available and 'published' as a service – MES and ERP systems.
- The communication languages utilized belong to OPC UA, MQTT and http REST standards.
- Pilot projects by our customers to validate the integration of the data collection and analysis systems.

Smart services

Digitization of products includes the expansion of existing products, by adding smart sensors or communication devices that can be used with data analytics tools, as well as the creation of new digitized products which focus on completely integrated solutions.

By integrating new methods of data collection and analysis, companies are able to generate data on product use and refine products to meet the increasing needs of end-customers. IMA has today several solutions in its pipeline. Some of the activities described here below will allow the expansion of the assistance services:

- SMART App for interactive digital documentation – troubleshooting – training
- 24/7 Assistance

- Machine performance monitoring
- Condition monitoring: autonomous maintenance
- Support to the resolution of faults with the aid of augmented reality tools
- AR and VR tools for training sessions and data transfer
- Choice of a cloud platform to collect data from the field and relevant analysis

Smart Factory

A Smart Factory is an environment where machinery and equipment are able to improve processes through automation and self-optimization.

The structure of a smart factory can include a combination of production, information, and communication technologies, with the potential for integration across the entire manufacturing supply chain.

All these disparate parts of production can be connected via the IoT (Internet of Things) or other types of advanced integrated circuits, which enable sensing, measurement, control, and communication of everything that's happening throughout the manufacturing process.

Industrial Internet of Things (IIoT), cyber-physical systems and collaborative robots (cobots) are only some of the main topics of discussion under the mainstream of Industry 4.0.

IMA's vision of an intelligent factory is a place where the main production elements (tools, devices and machines) are connected in order to obtain a smoother production management, allowing higher flexibility and reconfiguration

Big data & Real-Time monitoring

The possibility that the use of data will open are almost infinite: production data in real time, life status of the individual components fitted on the machine, maintenance planning, activities traceability, virtual behaviors monitoring.

Among the various advanced technologies, some of which may still seem out of reach, the one regarding collaborative robots appear to see a remarkable spike in popularity. The main reasons for that could be their relative affordability and emphasis on safety.

IMA is currently developing a pilot project which sees the experimentation of collaborative robots, known under the acronyms Cobots.

IMA combine the use of collaborative robots to its automatic machines to ease, as an example, the job of the operators. Transferring the heavier and ripetitive operations from the operator to the cobot or to delegate some control and adjusting functions. IMA's main objective of this pilot project is the realization of robotized cells.

From Robots to Cobots

The so-called cobots can today work together with humans without requiring safety fences or segregated factory floor areas. Even if cobots still have to comply with ISO safety standards and certifications if fences are no longer required between robots and humans, the direction is now clear towards a completely new and highly productive approach.

IMA laid the foundation for the development of a new project, which will see the first human-robot collaboration in the packaging industry. With the avail of highly sophisticated software and 3D vision system, IMA developed the algorithms to guide the cobot to recognize the right object, pick it up and install it directly on a packaging machine.

In this way, the cobot will carry out part of the job together with the machine's operator, assisting him with full confidence (intelligent industrial work assistant).

In this case, IMA is integrating more and different technologies to move a step ahead and making the whole system more flexible and reconfigurable, therefore giving the possibility to use the cobot for different functions by changing just the instructions.

Interviews with managers' of IMA headquarters in Bologna

The strategic problem and how to cope with it

In the global competition, there is a growing relevance of producing hybrid products, that is products embedding many on-demand services for the client. These services are also a relevant part of the added value of the production process. Besides, they produce complex machines on-demand; it is something different and more engaging than a customisation of the product. It means that each machine should be designed largely ex-novo.

Digitisation comes in handy. There is no long-term project for the application of digital technologies to products and processes. The time horizon is no longer than five years, Short (12-18 months) and mid-term (2-4 years) projects are in place, both included under the umbrella of the "IMA Digital" project.

In the short term, it is expected to work in favour of the greater application of digital technologies, especially in some processes of business management: renewing supplier management systems, improving data interchange and managing information, warehouse efficiency, after sales service with 24-hour help desk, access to tablet computer documentation.

As far as the medium term is concerned, the company is engaged in two co-financed projects, the first being from the national, the second regional. The first project mainly aims to evaluate how it is possible to increase the "intelligence" of the machines produced by IMA using sensors that can say more about what the machine is doing, both to an operator and to the machine itself which is prepared to provide feedback to modify the trend in progress.

The second project, co-funded by the Emilia-Romagna Region, concerns the efficiency of the production chain through digitisation, which provides for intervention on various subjects and activities: suppliers, deliveries, goods revenue, internal process testing, material management, technique. In essence, the entire process from order to supplier to delivery and assistance, a vast panorama where IMA has already done so much, but still finds ample room for improvement.

Compared to long-term prospects, uncertainty is high and, overall, emerging technology possibilities are assessed both as opportunities and as risks by managers interviewed, as well as discordant visions and points of view, depending on the role played and the skills they possess.

Opportunities are:

1. Dematerialization of administrative, bureaucratic processes, sharing of designs in electronic format with supply chains

2. Data Analysis of Used Machines: Opportunities for New Customer Service for Predictive Diagnosis and the Company to Increase Knowledge of Potentially Useful of All Machines Sold In The Long Term And Knowledge Of Direct Operations By Customer same
3. Collaborative Robot: Innovative Opportunity for the Company, Some Customers Begin to Ask, R&D Activities are underway on this
4. Virtual commissioning: machines are designed in 3D and can be tested on the PC, so manufacturing and production parallelisation can be made with production time shorter
5. Virtual Reality (also immersive) and increased reality: for training and assistance.
6. App, Helpdesk, Man-Machine Interface for Machine Function Monitoring and Troubleshooting, Contact Support.
7. IOT: wireless probes that communicate the quality of the process

Risks (for the company and the regional production system as a whole) are:

1. Mass Customization and Re-configurability: Mass customisation requires more reconfigurable, slower, but more readily compatible, machine modification of some packaging aspects. This would lead to the production of fewer machines capable of carrying out more activities, potentially causing a sharp fall in production volumes.
2. Additive manufacturing: risk to the company that has significant revenues from spare parts and risk to the production system as the necessary skills are radically different from the existing ones; this in the case of providing the customer with the opportunity to produce spare parts for him in 3D.
3. Collaborative and non-robotic robots: risk for the occupational impact of the economic system using the most robust new line.

It should be pointed out how the IMA Digital macro project represents the commitment to devote resources to innovation and look to the future after a few years of thrust growth where the priority of the entire organisation was ”making machines, make the machines ”.

Their projects are divided into four lines:

- the Smart Factory
- the insertion of Intelligence into their products
- Post-sales intelligence development services
- The Digitalization of the Supply Chain

Skills and competencies

The theme of changing the skills sought by the company is more relevant and complex. On the one hand, for some years, there has been a growing integration of competences in different fields of science, especially in the case of the production of automatic machines for mechanical, electronic, computer and chemical-pharmaceutical skills. In particular, the technical offices were changing because the knowledge about electronics and computer science alongside the traditional mechanics, but not only, was increased. The interaction between design and assembly is therefore increased. Namely, engineers and assemblers more and more co-develop the machine. Engineers intervene directly in the event of machine malfunction: "the divide between software and machine operators will disappear; also because the good software operator adjusts the machine, that is what the mechanic once did."

In addition to the integration of existing skills, the challenge of acquiring new skills, in particular, those relating to the use of collaborative robots, as part of the company's products, is also highlighted. For the enterprise, these are radically new knowledge, which is trying to acquire primarily through R&D investment, co-funded within a national project. In some cases, external expertise is used, but only temporarily to acquire new knowledge from the enterprise, mainly because some technologies change very quickly so you must try to absorb them promptly. It is challenging to find professional operators, namely the ones with intermediate skills: those with only the diploma are considered not skilled enough, while those with a specialised degree are too much specialised to be utilised in many different work roles. In many cases, the ideal solution should be to have courses delivering intermediate skills mixing industrial and computer science competencies.

Finally, the additive manufacturing technologies pose a severe risk of obsolescence of subtractive manufacturing know-how, if in the future the former is to develop it could lead to a significative employment reduction, within the company itself, but especially in the regional economy.

Employment risks

These at the moment are not directly reputable. Because in IMA's case, business processes can be improved by digitising, but there is no possibility of replacing functions or activities by machines, so no negative impact is expected. On the contrary, it is anticipated increase in employment in the R&D and design phases, resulting from the commitment to dedicate to the production of collaborative robots and smart machines.

On the other hand, it is possible to point out that the company is working on the creation of robots that, once completed, could replace some of the currently carried out tasks of an operator within customer companies, such as replacing the coil. There is, in fact, the demand for more robotic, where possible, aimed at eliminating some manual activities.

Interviews with workers of Ima companies in Bologna

Overlap between management and workers objectives

In general, the degree of overlap between workers' and managers' objectives is not so strong. The union representative always refers to the firm using the third person 'them', as opposed to 'us'.

Job rotation, degree of mastery of the production process and assessment

The organisation of the enterprise is the workflows are very similar to all the companies of the IMA group, and it depends on the requirements of the packaging manufacturing. The workload is very high. The working pressure is very strong, and the reason lies in the enormous growth of production volumes for which they are in a continuous state of emergency. At the IMA headquarter, and only there, there is a trade union agreement that defines the criteria for the category changes, if the union will deliver the request. The majority of cases are instead of management's initiative; this is the norm for the other companies of the group. Trade union representatives are also informed of the planned changes

Degree of participation in the production activity and training activity

There are different policies on training in the various establishments, but there are also some constants: language courses are considered almost an institutional task, like those on safety, provided by law. Then there are professional courses differentiated between designers, workers and clerical workers. For the designers, the courses concern the use of CAD, and there are moments of presence in the assembly and testing production departments to familiarise themselves with the operations. For the designers there is, for example, in GIMA, the possibility to participate also in university courses and to attend courses at the request of the worker; the request must be approved, but it is generally. For the workers, the professional courses vary depending on the job.

Hierarchical structure

Teams, when they exist, are functional units of internal articulation of the single macro-functions. There is a positive judgment on the climate within the functional units, while relations with the top functions appear to be very stressed. Teamwork, when it exists, is informal.

Technology and working conditions

The interviewed workers do not have direct opinions or experiences regarding the employment consequences of ongoing processes. In some cases, they say they do not know how to imagine what consequences there will be.

On skills, they start to perceive some of the consequences of the older digitalisation processes – both the CAD/CAM – and the new ones. There have been workers who have asked to switch from design to production to not have to learn to use 3D CAD. The significant innovations are focused on the work of designers. The company invests in advanced training in the use of advanced CAD systems on designers for 3D printers that require a radical perspective change for the designer. 3D printing allows time-saving avoiding the path that requires the traditional construction of parts with minor or greater iterations of the process. 3D prototype printing speeds up the process. On these technologies, there is a favourable opinion of the concerned workers who find it of great help. Workers' training on 3D printing lets them see the possibility at some point in time to switch from prototyping to finished parts.

The workshop departments are aware of the more advanced use of the connection technologies between the machines and computers of the technical offices. For this reason, there are complaints about the lack of generalisation in utilising these possibilities. For example, the ability to have 3D drawings on a computer that in assembling sophisticated machines, such as those they sell, would help a lot.

There are various testimonies about the working condition in the use of digital technologies.

The first consequence is an increase in employees' availability. The second is the spread of new ways of working such as the use of man-machine interfaces that, unlike the past, allow to see and operate on machines they sell even at a distance, for example using a Skype contact with Japan. The devices sold are all equipped with sensors and can-do self-diagnosis, collect data and allow remote control, with the possibility of providing teleservice.

In the internal work process, smartphones' and tablets' utilisation is growing, and advanced management systems have been introduced. Classical management software and SAP are used, but an M.E.S. system has been introduced. They can send to the customer's M.E.S the processing data of the making of the machine the client has bought. This possibility is essential in the pharmaceutical sector as it is part of the documentation that the customer must keep for ten years for the marketing of the product processed with that machine. This information also applies to other customers who are interested in the efficiency parameters. They can build Virtual Private Networks (VPNs) with customers to remotely install machine software and its update, what is very complicated in the pharmaceutical industry.

The effects on the work of designers are more dependent on the nature of their orders, which are often customary and involve a lot of work. They have a large number of orders, and each customer has very tight requirements for delivery times. Technology when it comes to reducing time helps. In the workshop, the situation is similar. Different is the case of connectivity technologies which, through availability, loosens the distinction between working time and private time.

Union organization

There is a clear distinction between the opinion on the union external to the company and on the RSU and the delegates. On the "external" union there are positive opinions full of many, but also very radical critical reflections and a general critical evaluation of the relations between the workers and these and the union. An overall positive assessment by the employees of the delegates and the RSU or of the delegates on their relationship with the employees, with some critical notes.

2.5 LAMBORGHINI MANUFACTURING

Lamborghini Manufacturing produces Super Sport Cars and SUVs. It is owned by Volkswagen. In 2017, it had 1.500 employees; in the first six month, it delivered 2091 cars.

Interviews with managers

The strategic problem and how to cope with it

Lamborghini added a line to produce a SUV (URUS), but it implies a new business model compared to the traditional one - the Super Sport cars (SSCs) - with entirely different features, such as higher production volumes.

They moved from the conveyor system to a line (SUV URUS) based on AVGs. The assembly-line is horseshoe-shaped, with the pre-assembled parts organised in rays; the bodies travel on AVG mobile platforms.

The advantage lies in twofold flexibility: a) the line is reusable for new products without needing to rebuild foundations, etc.; b) if a body has severe abnormalities, it is moved offline without needing to change the *Takt Time*.

The company decided to use the new assembly line to experiment with all the digital design and process technologies and new organisational concepts to gain maximum flexibility. Testing will serve to change also the SSC lines when new products are added. Traditional lines are “old”: 2007 and 2011. This model needs a complete system digitisation with standard on-board PLCs and distributed intelligent software (cloud) to interconnect the equipment via MES-SAP data collection system.

The new factory will be completed with the new painting area will not be organised in line but based on multiple cabins operating in parallel (islands). Each cabin “calls” the piece to be painted and if the piece has to undergo more paint jobs, it is returned to the waiting area where it will be “called” from another cabin at the right time. All are connected to MES.

Besides, the new organisational model allows the Lamborghini management to ask for a pre-defined range of acceptability of the OEE index to the suppliers.

Following the lean production model, they are aiming at reducing all non-value-added activities by improving the ergonomics of workstations. The digitalisation allows the possibility of using avatars, that is, the representation, through wireless sensors, of a worker’s movements to measure their indexes (rotations, torsions, etc.), and their frequency, with extreme precision so that they can evaluate individual positions according to the German system Ergo AWSS. The point still unresolved is the calculation of forces; they are using a glove, but in their opinion, it is not up to the standard of other measures. They are studying the AUDI system that looks promising.

Skills and competencies

An essential aspect was the widening of the skills of the different production areas. For example, the rigid separation between production and supply chain management has been overcome by shifting supply chain management from logistics to various production areas. More generally, a series of corporate functions have been brought closer to the production lines.

The internal situation is favourable because, thanks to the average age, the overwhelming majority of workers participate “enthusiastically” in technological experiments.

The company uses the traditional methodology of supporting newcomers by an expert operator. The new technologies allow new possibilities to widen the skills for a higher number of employees.

Digital simulators, for instance, were used to simulate to the operator and supplier how to apply, before the actual implementation, the new digital processes. For example, they should become accustomed to the fact that if an employee uses a wrong screw or tool, the system will correct him/her. This simulation was possible by using the 3D computer-aided design tools, already available, directly in a specific lab. This method, now used only for simulation, will be progressively extended to the actual work positions.

They had to modify, with the new line, their traditional approach to the promotion of internal resources. They had to resort, in particular for the clerk and technician positions, to the external labour market on higher professional bands. Therefore, in the face of insufficient available external resources, they had to be equipped to improve Lamborghini’s attractiveness as a workplace.

They have a five-year program, with annual review, of human resource needs; such programming is very detailed, up to the job description of the single cost centre. The ”Human Resources” function solely covers the formation of soft skills while technical training is the responsibility of the industrial training centre.

The person in charge makes the individual evaluation according to parameters known to the employees of his/her area. The outcome is annually returned to the employee indicating the areas of improvement deemed necessary. Employees who can access SAP have their online evaluation available and can interact with comments.

The evaluation consists of two parts:

1. Objectives assigned to employees.
2. Individual soft skills

For managerial career, technical skills are excluded.

For everyone, the score ranges from 1 to 5 (A-E).

There are calibration adjustment mechanisms based on qualitative evaluations. These are done within each Direction.

Interviews with workers

Lamborghini is among the most representative examples of the introduction of a series of technologies related to the categories of Industry 4.0. The key element triggering the introduction of Industry 4.0 is the conceptualization of a new product, namely the 'Urus' SUV. In this firm the adoption of Industry 4.0 is therefore strongly linked to a product-process nexus. The investment plan has been funded by the owner, namely AUDI, in 2015 just before the explosion of the so-called 'Diesel-gate'. Since none of the Lamborghini products rely on a Diesel engine, the contraction of available funds after the scandal did not affect the initial investment plan. Albeit the change in the ownership structure occurred in 1998, the push towards an automated organization with state-of-the-art technology started only in the last decade, and influence from AUDI constituted a core element in reshaping the organization of production from an artisan factory to an industrialised firm. In this respect, the introduction since the early 2000s of two parallel assembly lines, which recently became three with the Urus SUV, has been a key strategic decision for the dynamic of the firm. In order to fully understand the reasons behind the 'textbook' Industry 4.0 plan undertaken by Lamborghini, it is important to notice that the firm manufactures final luxury automotive products, and that its demand has been literally exploding during the last 5 years, with only a slight contraction in sales occurring in the period 2009-2011 and getting back at pre-crisis level in 2014. The sustained increase in its products demand resulted into a 5-fold increase in the workforce, from around 300 to 1500 employees over the last 15 years.

Given this overall picture, workers manifest a general optimistic feeling about the evolution of the firm, in terms of both the internal organization of production activity and the process of external growth. Expressions like "Since I have been hired in Lamborghini everything keeps changing: the assembly line, the organization of work, the number of buildings, colleagues" are quite common. Therefore, a widespread feeling of "process of change" is overall present, and this is true both across tasks and organizational units.

Overlap between management and workers objectives

There appears to be a strong overlap between workers' and management's objectives. For instance, even the worker representative keeps referring to Lamborghini using the first person 'we'. Many workmen report a strong sense of membership and even of pride: "Lamborghini is a factory wherein you do not work as in factory-system: rhythms, times, responsibility and freedom of work are very different from Ducati, where I happened to work before."

Job rotation, degree of mastery of the production process and assessment

Job rotation at the level of each production phase is a common practice, and the takt-time is not perceived as 'pressing' or irrevocable: rather than executing single repetitive tasks, workers perform a list of several tasks, contained in a so-called 'folder'. They are free to take a break once the program is accomplished. Along each assembly line it is not uncommon to find workers that are able to operate on several different phases in complete autonomy. Their level of mastery is formally evaluated by means of a so-called 'flexibility matrix', reporting grades with respect to each worker's knowledge of each single stage of the process. The grading is updated once a year by the supervisor, and takes into account three aspects: i) whether the worker is currently receiving training for the specific stage, ii) whether the worker is able to operate the stage in complete autonomy, iii) whether the worker is able to train other workers to operate on that stage.

Job-rotation does not simply include movement along the same assembly line, but also horizontal mobility between different organizational units: it is not uncommon to find workers that maturated experience in seemingly unrelated departments. Overall, many workers have a high degree of knowledge about the whole production system.

Degree of participation in the production activity and training activity

Workers participation in management is highly encouraged and takes place by means of both a scheduled and an unscheduled procedure. The so-called 'team-work' is a monthly meeting in which each small team gather and discuss about news, improvements, bottle-necks, and the like. Besides that, workers are continually encouraged to submit their proposal to improve the production process, the so called "management of ideas". Bilateral technical commissions are a normal practice to establish rhythms, times and methods.

Once hired, each worker receives on average two weeks of on-the job training. Along this traditional horizontal training, some vertical training has been recently introduced and takes place in a few training-room purposely built adjacent to the assembly-lines.

Hierarchical structure

Each team consists of around 12-15 people which are coordinated by a Team Leader (hereafter TL). Remarkably, many workers across different departments have reported that their TL is not especially expert of the underlying production phases, but rather acts as a coordinator with bottom-level managerial and soft skills: "The TL is not the most competent worker; he is chosen by the management as a communication channel". In many cases, the worker directly interacts with the head of the department, effectively bypassing the TL. Therefore, the organizational structure does not appear exceedingly rigid. Nonetheless, the TL evaluates the performance of the workers within his/her team.

Technology and working conditions

Inside this ‘ever changing’ environment, workers report many improvements in terms of working conditions, particularly related to ergonomics. Apart from AGVs, workers reveal that collaborative robots actually support their working activities. This is particularly true for the new SUV line. Nonetheless, the degree of robotisation is deliberately maintained low as the firm wishes to preserve its reputation of handmade crafting of high level luxury cars. The MES software has just been implemented, and workers generally show a welcoming feeling because of the widespread use of tablets along the assembly line. They do not signal, at least at this stage, any fear of being exceedingly under surveillance or overly scrutinized. IoT naturally results from M2M connections. Nonetheless, massive data collection is currently not regarded as a fundamental activity. Big-data require substantial resources to be thoroughly analysed and in this respect Lamborghini is still at an early stage. There are plans of devising a business intelligence unit in the future, with the aim of making sense of these data.

Union organization

Trade unions are unanimously regarded as very powerful by both blue and white collars. “Lamborghini is the best place to experiment Industry 4.0. Trade unions have been crucial in accomplishing that”. Union representatives have been quite active in mediating the process of technical change: specifically, they have been very effective in demanding ergonomic improvements. In the current phase, they are negotiating the level of application of Industry 4.0 technology: they are proving able to govern the introduction of the MES, signing a firm-level contractual agreement which states that the MES should not be used to control workers. Additionally, since the introduction of the third assembly line, they are requiring not to increase the takt-time, but if necessary to introduce a Sunday shift. Rather interestingly, some office workers are manifesting a new interest toward trade unions: this phenomenon has been triggered by the attention devoted to the issue of smart-working on behalf of white-collar worker.

2.6 BONFIGLIOLI GROUP

Bonfiglioli Group has 3.632 employees (half in Italy). Since 1980, it is experiencing a global progressive expansion; in 2017, the Group owns 13 plants in India, Slovakia, Germany, Vietnam, China, USA and Brazil.

The company produces gearmotors and gearboxes, wheel, track and travel drives, slew and winch drives, other hydraulic solutions, electromobility solutions, wind solutions, electric motors, precision planetary gearboxes, inverters and energy recovery, human-machine interface.

The main business areas are:

1. Power transmission solution for wind-turbine yaw and pitch control;

2. Power transmission solutions for mobile machinery. It includes Products for applications such as construction, mining, agricultural, forestry and earth moving equipment as well as products for marine and off-shore applications. This business area also includes hybrid and electric solutions for applications such as material handling.
3. Power transmission and mechatronic solutions for industrial applications.

A whole section of the web page of the group is devoted to the EVO Project:

> EVO project: the next EVOlution of its business to Industry 4.0:
>
> The EVO plant will be located in the "Clementino Bonfiglioli" area, measuring 148,700 sq.m., in which, by 2018, the foundations of a modern factory will be laid. Including the current Calderara plant, when fully operational, the EVO plant will cover an area of 58,500 sq.m. with 56,000 sq.m. of green areas and forecourts.
>
> The EVO project is part of a series of strategic initiatives aimed at consolidating and improving the market position of the company, already one of the largest manufacturers in the industry worldwide.
>
> The company's growth is already clear to see, following the excellent results of 2015, with a turnover of 730 million euro. The company is aiming to achieve a sales target of 780 million this year, to fully confirm its leading position in a wide range of application fields.
>
> The recent acquisition of the German company O&K Antriebstechnik GmbH and the expansion of the Forlì, Italy production plant have contributed to increasing the competitiveness of the Group as a whole, as part of the ongoing renewal and development of its production processes and product offering.
>
> Once completed, EVO will have absorbed investments for 60 million euro overall, divided into the following areas: 30 million in new production technologies in line with Industry 4.0 best practices, and 30 million in infrastructures. This will make EVO the long-term point of focus for Bonfiglioli's competitive growth strategy in the field of industrial processing and handling products.
>
> When fully operational, the production lines will have a capacity of 800,000 units a year and will employ 600 workers as a result of the integration of all industrial activities that are part of the Industrial Business Unit, currently split among Calderara di Reno, Sala Bolognese and Vignola, Italy plants.
>
> Bonfiglioli Riduttori was established in Bologna sixty years ago, thanks to the extraordinary entrepreneurial capacity of its founder and its location in an area with unique industrial know-how. Its success has known no limits: efficient processes, product quality and human resources are, now as then, the keystones on which EVO will be built.
>
> The project is founded on respect for the quality of life of the workforce, with a Barrierless Factory concept intended to integrate all areas of production and the social life of Calderara di Reno.
>
> EVO is designed to satisfy the most recent energy efficiency standards, offering outstanding performance regarding environmental impact: the site will be planted with 455 trees and 3000 sq. m. of roof gardens, and the expansion itself is designed to be zero energy. In other words, it will generate more energy than is required by all buildings, produced locally using renewable sources. Indeed, EVO will be powered by a 3 MW peak power photovoltaic plant, mounted not only on the buildings' roofs but also on the awnings of the staff car park.

Interviews with managers

The strategic problem

The new EVO plant is designed to be equipped with new assembly lines with the following requirements:

1. the lines should be able to self-regulate to dynamically changing external conditions;

2. the lines should be able to work on the principle of one-piece flow;
3. on the lines, the worker will be assisted by a distributed system of intelligence acting also as a tutor, utilising the visual management techniques. They will utilise Human Machine Interfaces (tablet, smartphones) to know in advance the tasks to be fulfilled in the next 2-3 hours.
4. More output with the same level of stuff
5. The data collected through the digitalisation of the processes, and the utilisation of IOT, will be analysed with the Big Data analytics technique.
6. the fundamental principle is that the customer satisfaction is more important than the technical efficiency of the system;
7. accordingly, the new plant should be able to adjust the output to the market demands in two weeks' time.
8. The system will be managed by M.E.S. which is under implementation also in the old plant.

To accomplish these goals, a new assembly logic will be introduced. Each working station will be designed according to ergonomic principle and reducing all the non-added-value activities through the utilisation of AGVs, as in the Porsche plants, carrying the specific kit of parts and tools for the operation to be done. The AGVs will be equipped with collaborative robots. They are looking for suppliers of the robots; they are searching for very easy to handle interfaces. All tools and parts are in a range of 60 degrees for ergonomic reasons. The warehouse will be reorganised to speed up the lead times and to reduce the W.I.P., not in absolute terms but as a percentage of the total output. They are planning the utilisation of 3D printing for prototyping to reduce lead times and to implement forms of parallelisation of designing and manufacturing, according to the principles of concurrent engineering, reducing lead times.

They started two years before the actual realisation of the new plant to teach the suppliers how the system will operate. It is up to the suppliers to organise their plants accordingly; it is not the business of Bonfiglioli to advise the suppliers.

These requirements are the rationale at the basis of the collective agreement signed in July 2017

In the last part of this subsection, we are giving some excerpts from the Italian 2017-2020 agreement with Trade Unions.

2.3 Participatory system

The participatory system is based on the setting up of specific Bilateral Technical Commissions, which must be a forum for discussion and discussion between the Parties on the subjects covered by them.

Such technical committees in their field of activity will have advisory, informative, preparatory, processing and propositional functions, and having no negotiating roles will only serve as a support to the Parties unless otherwise agreed subsequently.

The commissions described above will be constituted by the same number, for each of them, as follows. Commissions will have an experimental nature for the term of the current Agreement and will be composed of members of the RSU in office. Provincial Trade Unions will designate the members of the company's trade union members. Within the RSU members together with the appointment of alternate members (1 per member for the Commissioner-members and 2 for the

10-member Committees).

Each Commission will have the opportunity, after an agreement between all the members, to avail of staff members who are not members of the RSU or the Corporate Management, as well as external experts who will be able to access the Company before the authorisation of the Corporate Management.

Before the commissioning of the Commissions, the Parties will evaluate and define a specific training path for the members of the Commissions themselves and their respective arrangements, including the delivery of useful materials to carry out the tasks assigned to them.

The Commissions will meet in the face of a timetable that will be defined by the Parties according to the priorities identified, or at the request of one of the Parties within two weeks.

Given the nature of the information that will be provided, the members of the various commissions as well as the business union delegates (RSU / RLS), the representatives of the OO.SS. And their experts (external and internal) are committed to confidentiality and are required to strictly respect industrial secrecy in respect of all facts, data, processes, acts which they become aware of in the performance of their duties, as established by art. 2105 of the Italian Civil Code.

The Parties shall define the following Commissions:

- Training and framing committee
- Equal Opportunities Commissioners and Employees
- Commission for the organisation of new products work
- welfare commission
- Award Program and Improvement Systems.

As to the Commission on labour organisation and new products

This Commission will be organised with the involvement of an equal number of members of the staff and the managers. This arrangement is because the Parties will not assign to such a Commission a pure advisory or analytical role, but the ability to contribute concretely to improving the quality of the products, the efficiency of the processes and more generally the organisation of work, also by the provisions of Art. 55 of D.I. 50/2017 converted into Law 96/2017.

The task of the commission will be:

- encourage the implementation of initiatives aimed at improving the organisation of work and work activities and the efficiency of processes;
- deepening the functioning of the organisational model and modalities of the performance;
- analysis of the development of new products and industrial projects; mapping and intervention on the impacts they might have on the activities/production modes;
- the prospects of industry 4.0

This joint production unit will consist of 4 members, 2 of which are nominated by the Company and 2 RSUs of the single production unit, designated annually by the provincial secretariats (2 B3, 2 B6, 1 B7 substitute, 1 B6 substitute).

5.2 Permanent training and right to study

The Parties consider strategic investment in training aimed at enhancing professional skills, also in the light of changing jobs, in connection with the technological and organisational innovation of the production and labour processes.

About the provisions of art. 8, Section IV, Title VI of the CCNL Metalmechanics, Parties do they undertake to give information on the right to study and to encourage the use of their paid leaves by the workers who intend to improve their culture by acquiring further qualifications.

It is crucial for Bonfiglioli to effectively guard some key areas able to increase and support the consolidation of a leadership position in the market of power transmission. In this respect, a scholarship will be recognised for the employees who, while keeping their employment relation, they will obtain a legally recognised qualification (omissions).

Interviews with workers

Bonfiglioli Riduttori is currently experiencing a phase of transition in terms of market demand satisfaction: in particularly, it is moving from an old-style inventory management, towards a just-in-time system. As a matter of fact, even today there is no strict tack-time enforced. The production activity entails plenty of phases with little value added, comprising the transportation of both equipment and components.

The firm has experienced a long phase of stagnation, since the 2008 crisis, with prolonged period of redundancy fund, thereby reducing individual working time. Since the couple of years the firm decided to invert the decadent trajectory with a new phase of investment and market demand management. In this framework, the EVO project has to be understood.

The internal organization of the firm clearly reflects the shift in ownership, still in the hand of the Bonfiglioli family, from the old style enlightened master represented by the initial funder, to his much more market-oriented and management respondent daughter.

Overlap between management and workers objectives

In general, the degree of overlap between workers' and managers' objectives is not so strong. The union representative always refers to the firm using the third person 'them', as opposed to 'us'. In fact, even though there is a general constructive environment, many organizational participation practices are still rather underdeveloped. There is a strong degree of solidarity among workers, who do not appreciate potential incentive schemes fostering competition.

Job rotation, degree of mastery of the production process and assessment

Job rotation is not a standard practice: many workers have been operating the same tasks for many years. Within many phases, workers execute repetitive and often rather arduous work, especially for women. Workers typically do no talk too much to one another and show little knowledge about the overall production process. Given this low degree of job rotation, the production process is heavily dependent on the individual know-how, meaning that, in particular for the mechanical production unit, the absence of a single worker might arrest the production itself.

The schemes of performance evaluation are not clearly defined and a high level of discretionary practices regulates both horizontal and vertical mobility.

Degree of participation in the production activity and training activity

There is no formalised practice inducing workers to participate to the production process design: team works have just been introduced. Some workers, in particular maintenance technicians, have received formal vertical training consisting in formal class-hours. But this is far from standard practice and strictly depends on the task performed by each single worker and its relevance within the production process. There is no formal practice to collect workers suggestions aimed at improving the production system: "After 5 years passed since I asked for, I finally received a basement window cart to reduce the effort."

Hierarchical structure

The hierarchical structure is rather strict: "You do not have to think, you only have to execute" is a statement reported by a worker which well summarizes the degree of hierarchy in the factory. The heads of each single unit are in fact called "men with apron" to signal their alignment with management interest as opposed to the workers'.

Technology and working conditions

The introduction of Industry 4.0 basically consists of process innovation, and productivity enhancing investments, mainly by means of the MES. Its main objective is to streamline the production process, to identify the machines more prone to defects, and to understand the reasons of machine interruption, rather common during the working day. The man-machine relationship is not without contradiction: some operators reported their ability to slow down the machines, even those belonging to the latest generation controlled by the MES, if 'needed'. The ergonomics advancement in the last years have been registered particularly in the mechanical production unit where some tasks are now performed by robotic arms.

Union organization

Nonetheless the relatively underdeveloped level of horizontal practices, the degree of unionisation is rather strong and cohesive: many workers have reported their participations to conflictual episodes, related to worker resistance to outsourcing and relocation of some production units in other plants. In general, the unique union representation is showing particular ability in managing this new technological wave, with particular attention in preventing the use of the MES as a form of control.

2.7 TOYOTA MATERIAL HANDLING MANUFACTURING ITALY (TMHMI) – FORMERLY KNOWN AS CESAB

From Cesab website:

CESAB Material Handling Europe was founded in 1942 in Bologna, Italy and our customers have been at the heart of our business ever since then. With its corporate head office and sales support in Bologna and marketing support in Brussels, CESAB has a wide network of 120 independent dealers across Europe to make sure you have excellent service and support whenever you need it.

Our customers receive the highest quality of support from CESAB and our network of dealers with the following services:

- Consultations during the forklift selection process
- Operator instruction
- Safety inspection
- Preventive maintenance
- Genuine spare parts sourcing
- ASEC (After Sales Evaluation & Certification)
- Repairs

Our forklifts are designed, manufactured and tested in Europe in our factories in France, Italy, and Sweden using the best manufacturing processes in the world.

- Highest quality
- Increased flexibility
- Shorter delivery lead times
- Reduced environmental impact

Interviews with managers

From their point of view, the organisational rather than the technological leverage has been more critical. Cesab was acquired by Toyota, and they had to work to also culturally transform the way they work to switch to the Toyota Production System (TPS). On Industry 4.0, as far as production processes are concerned, they have no defined overall project, but, from a technological point of view, they are evaluating the passage of their forklift to a hydrogen fuel cell motorisation. Of the technologies registered as Industry 4.0, "we have been using, for some time, 3D printing to make plastic pieces for prototypes and to support a department, which is a factory in the factory, which is responsible for producing special lift truck that is, those with a high level of customization."

The situation about the forklift is different. Most of those trucks are not purchased but rented, so TMHMI has an impressive fleet of trucks, worth about 24 million euros. These trucks already send operating data that is used by them for fleet maintenance.

They are thinking, but there is not yet a concrete project, on the use of augmented reality for warehouse workers and to replace the plethora of existing digital personal tools with tablets.

They are thinking about how to use the Cloud.

Their fundamental problem is the absence of common standards on computer networks and 3D - CATIA design programs. In Toyota, in fact, there are no common standards, recently the situation has evolved, and today there is a convergence between the plants in the Bologna area and the Swedish ones, on the one hand, and that of Anceny, in France, and the Japanese headquarters. The sales companies in the Toyota group use the M3 software. The designers use CATIA, but the release in use in Japan and Italy is the same, and therefore you can exchange data, while the Swedes have a more advanced version and, thus, there is no way to transfer data. The decision to upgrade the software has already been taken, and it will take maybe three years, given the considerable number of computers in the group, to make it all happen.

They are thinking about the digitalisation of the company and are evaluating the use of the super-amortisation allowed by law, but there is not yet a defined plan. From his point of view, the digitalisation project has to deal not so much with technological issues, but with organisational problems; it is a remarkable undertaking from a corporate point of view. The exchange of data with the trolleys for now only concerns the use of batteries; other data today are not exchanged because there are security concerns.

Finally, the manager interviewed points out that in the culture of Toyota management the order of importance is: production, the internal research and development system and, finally, finance. Toyota has interest in technology but with a different approach from the European companies; in short Europe and its industrial programs are of little interest to Toyota.

Their functioning is based entirely on organisational architectures, assisted by MRP type software. They use the “frozen sequence” of two weeks, i.e. the supplier has the programming and the sequence of its supply in advance of two weeks, then the cycle of the assembly of the forklift, takes 3-4 days, and finally its shipment. The total lead time is one week, they produce 75 trolleys a day and empty the warehouse from 18 to 20 times a year. A key aspect of the supply is that of the masts of the forklift that are supplied to them and to the French factory from the Ferrara plant which produces 24,000 per day.

They consider the suppliers as strategic partners and therefore there is a specialised team that supports the suppliers and assists them on the organisational level, having as a model the TPS. They also make investments on suppliers to foster their development. In their strategy, suppliers must be geographically close; 70% is within 200 kilometres, except for supplies coming from Toyota plants and those that are not available in this geographical area.

They use the M3 software as a management tool. The scheme is: order of the trolleys – planning and procurement define the production plans with the related processes of the suppliers. At the moment, there is no specific digitisation project.

The Swedes are developing a test on the use of Big Data analytics, and some employees of the Bologna plant participate in the working group.

Interviews with workers

Recruitment

Regarding the recruitment practices in force at CESAB-TOYOTA there has been a change in channels and recruitment methods over time. The traditional/informal recruitment channels of the past have been replaced by interim agencies. The interviewees argue that there has been a worsening of the contractual conditions of entry, but they note that often the path results in a permanent employment and stabilisation (agreements have been made on this point). In the clerical tasks, channels with universities and technical institutes have been opened for the use of trainees, interns and undergraduates. In other words, CESAB tends to use hybrid figures in work/training during trial periods. These channels, however, have a non-high degree of structuring (no real courses have been established in partnership enterprise/school/university). The figures involved in the employment interview are those under the supervision of the foreman and the person in charge of the personnel, but in production, the foreman seems to be the one who has the strongest position in evaluating the worker, while the personnel manager deals with administrative matters. There are brief ”technical” tests in which the recruits are tested. The absence of precise selection criteria in the recruitment phase and the superficial assessment of the worker by the CV and his technical skills allow wide margins of discretion to the management. This discretion is assessed in an ambivalent way by the interviewees: on the one hand, are wary of the adoption of criteria based on tests, questionnaires, etc., on the other side they believe that this discretion is one of the conditions producing favouritism and injustice during recruitment.

Training

Training that takes place during the recruitment process has not been negotiated by Unions. In general, training for production workers is considered inadequate and not sufficient. The recurring technical training carried out after the recruitment period was negotiated and obtained after a discussion with the company. The technical training carried out annually mainly concerns the update on new products. In general, the interviewees believe that training at CESAB is not coherent with the ‘Toyota philosophy’. Training through rotation also seems to have been a practice used in the past but downsized. In summary, most of the training takes place on the job, but it is scarcely formalised and realised through individual initiative. The issue of the Jolly and the Team Leader deserves a special mention. According to the respondents, there is a problem of training for these roles. Team leaders and jolly must possess transversal and elevated technical skills, but these skills are usually acquired only by the experience. Another problem reported is the lack of presence of organisational and interpersonal skills (ability to manage groups for example) in the Jolly and in the Team Leader. These skills are considered very important. The problem, according to the interviewees, is the discretional selection of the person who must perform these roles.

Assessment and careers

The interviewees see the same informal and high discretional procedures in career steps. Workers are unaware of the existence of formalised skills assessment programs or formal career programs for those working in production. In this highly discretionary context, the team leader and the Head of Department have an important role in the assessment procedure on behalf of the HR manager. The Head of Department and HR manager have a formal decision-making responsibility on career steps, but the team leader has the possibility of favouring or restricting career steps for workers who fall within his domain.

Work organisation

In general, an ambivalent and partly contradictory assessment emerges from the adoption of the Toyota system at CESAB and its impact on working conditions and work organisation. On the one hand, they tend to emphasize the distance between ‘TOYOTA philosophy’ and actual working conditions and work organisation. Indeed, the interviewees argue that most of the problems encountered in the workplace derive from this inconsistency of CESAB to the Toyota model. On the other hand, however, they tend to believe that the Toyota model is excessively rigid: if it were rigidly applied, they say, the system would stop by generating macroscopic inefficiencies, indeed.

- Time Contraction – Moreover, since Toyota system has been adopted, working time has been drastically reduced, the operations have been standardised, and the work cycle has been strongly decomposed. For example, in 2007 in the inspection department, an island system was in force with a 19-minute phase and three stations; after the integration of the Toyota system, it has been re-designed in line with 10-minute phase and five stations; nowadays it is a 6.30-minute phase and five stations. The interviewees point out two consequences deriving from these transformations: less chance of time management by the employees and the reduction of work quality.
- Job Rotation – Mobility is almost absent from department to department, but job rotation occurs in some departments (e.g. inspection) and some offices. Nevertheless, a formal job rotation program doesn't exist.
- Kaizen – The kaizen system is fragile and not consolidated. In general, kaizen is declined as "fix it yourself". In fact, the interviewees describe episodes where the improvement or resolution of the problem has been carried out informally.
- 5S – the 5S system seems to be widespread in the factory, especially for the first three S (seiri, seiton, seiso, or to separate, reorder and clean). Respondents consider it significant that these operations are more and more often made by the workers in the minutes before the start of the shift and in the minutes following the end of the day.
- Kanban - Of course, the kanban system is adopted in production, but the interviewees say that the system does not work often. This is also accompanied by some elements of discomfort concerning the elimination of non-added-value times that the kanban produces, muda for the company, spaces of rupture of monotony and temporal pressure for workers.
- Asaichi – Some coordination meetings are held, and some interviewees believe that they are useful for carrying out the work. The meetings are mainly conducted by the foreman and problems are addressed here without attribution of responsibility to those who have committed them.
- Team Work – In general, the interviews reveal the partial absence of formalised group work practices. The only kind of group work is out of the procedure, spontaneously self-organised by the workers.
- Team Leader - Each team leader has a variable domain depending on the department: for instance, online the ratio is 1/24, in inspection 1/11. The team leader has the function of coordinating activities and has a strong power in the allocation of people along the piece of production of his domain (in this sense he has an indirect power also rewarding/sanctioning, as he has the power to regulate holidays and therefore absences). The team leader has the formal authority to stop the line and is the figure to turn to if you have a technical problem and can also intervene operationally to replace someone for an unexpected or urgent situation. So, the team leader must have a thorough knowledge of the whole process on which the employees are supervised. The team leader, however, seems to have also functions of horizontal coordination and not only of its domain.

- Jolly – The jolly, on the other hand, is a sort of everything to do / stage holes. This function requires the knowledge of the line even if not equal to that of the team leader and unlike the latter the jolly has no coordination function, nor he has the authority to command the employees. It is a figure that plays an active role in case of emergency or when it is necessary to maintain pre-established pace and speed.

Working condition

Actually, in production there are working times and very diversified conditions. However, from the interviews emerges a widespread criticality: overtime. The issue of overtime is one of the most important issues that emerged from the interviews. The company often resorts to overtime. In describing their conditions and working time in general, the interviewees often refer to the ability to manage the complexity of the border departments and to an inefficient production planning. In fact, several interviews are underlining that the irregularity of the input falls directly on the production workers, without any filter from the production planning, and this is precisely the source of the decrease of discretionary behaviours and control (albeit residual) of the times by the employees in production (irregularities that the interviewees claim to be also a cost to the company). The effects, in particular, are alternate and there is a periodic presence of non-added-value times, intensification of time and continuous demand for overtime, as already mentioned above.

Technology 4.0

The production process at CESAB has not registered significant technological changes during the recent years. Even products, although their customization has grown, do not seem to be equipped with 4.0 technology. However, if we consider I 4.0 as a digitisation process, the scenario changes. In CESAB, in fact, it is possible to identify traces of digitisation both in production and in offices, both in the local network and in the global network.

Trade Unions

Compared to other business situations and a general trend, the importance of the trade union in CESAB is undoubtedly significant, and the efforts of union representatives seem to be recognised by workers. However, from the interviews emerged a progressive weakening of the trade union representation and a growing difficulty in playing an incisive role. In this general context, some specific critical issues can be identified.

- FREE-RIDER - Firstly the (well-known) free-rider issue; what emerges concerning this typical ”trade union criticality” is that the overtime seems to have assumed an increasingly significant dimension and above all, the temptation to respond to this criticality through strategies of an associative/corporate nature is widespread.
- Criticality of Young Workers – Concerning unionisation and involvement in union activities, the problem seems to be young workers (often new entrants). Distrust, indifference, disaffection, individualism, fear, etc., are terms that often occur in the descriptions of the relationship between young workers and the union.

2.8 CEFLA

A cooperative company in Imola specialising in electrical and thermohydraulic systems. Today they are a multi-business international company with five Business Units:

1. *Finishing*: Producing finishing production lines, including painting, decorating and ennobling processes for wood, glass, plastics, metal and fibre cement.
2. *Plant Solutions*: Designing, constructing and servicing civil and industrial plants, with an emphasis on renewable energy.
3. *Medical Equipment*: Designing and producing dental and medical equipment.
4. *Shopfitting*: Furnishing solutions for supermarket chains and custom-made products for specialised stores.
5. *C-LED*: Innovative LED technologies and solutions for every need.

Cefla has 1.900 employees; 26 global production sites; 468.388.000 euro value of production, 46.819.000 euro EBITDA; 17.483.00 net income; 240.786.000 euro net equity.1

Interviews with managers

The strategic problem

The organizational context is very important. They are committed to providing consistent guidelines for the five business units (BU) - finishing (F), medical equipment (M), plant solutions (s), shopfitting (S), c-led (CL). There are still five separate companies, hence the progressive construction of an integrated light matrix, that is, of a corporate address, through competence centres, leading to standard processes and homogeneous structures. Among them the new Corporate Innovation & Business Value position, which is not an R&D function, but remains inside every BU. It is, therefore, a strategic function designed for searching for new business - as it has been with CL or looking for cross-integration - as it has happened with the use of CLs in Industry I and S. Where the integration process is later and for Operations & Services. These organizational elements are very important because every use of new integration technologies requires this starting point. They are still far behind Industry 4.0 for this BU integration problem.

There is a mix of continuity and radical innovation. This mix is because the speed of technological change has been much higher than the pace of technology adoption, and that is why they are beginning to use today technologies that have long existed. This mix varies depending on the business. For example, in building automation where the products of BU I and CL are crossed, or in the BU F there are elements of strong innovation; as well as in products with a strong presence of after-sales services.

They need software technicians; a profession that in his opinion is that of the future.

Smart Factory

It depends on BUs. Anyway, they are making progress.

They have introduced 3D printing for prototypes and plastic, but they are working on a kind of rubber, that is a soft material, to produce complex pieces inside the workshop in small and very particular batch production. They are also thinking of using 3D printing to build the processing equipment they use inside. 3D printing would allow the design of products and equipment to evolve together in a parallel design form.

They have introduced the Siemens PLM that manages from the design to the changes and upgrades; The advantage is that everything is done automatically by cascading, from the production of manuals to the updates for the vendors, for the transferring, etc. This system combines the performance of their Oracle ERP with MES systems; there is currently no CRM that should be integrated into the system in the future.

They are thinking of using collaborative robots. For example, in some areas, such as BU F, the problem is not productivity but flexibility. It means, for instance, to change the image every 5 seconds to a paint machine that advances 50 meters per minute. If collaborative robots can increase flexibility, then we must go on.

They have a reasonably advanced management of digitisation codes and RFID technologies for digitised pallet management. They are working on home automation, possessing already interactive lamps, energy saving and visual well-being of workers. They would map cart carriages to improve their layouts. They have introduced glasses for augmented reality in BUF.

Smart Services

HDI is a critical topic for them. They want to get to a service with remote predictive maintenance capability. This objective can be reached using their HDIs that provide both the data of individual machines and those of the lines. Even now, for example in cogeneration plants, there are ”synthesis lights” that say if there are any problems and where. A problem area identified you could go down to the level until you reach the single valve. It is this way that the weight of services can increase beyond the current threshold. They are designing adaptive HDI systems that provide more or less information depending on the badge the worker has. At present, they have standard HDI systems that can be customised. In the future, they want to switch to a generic technology that is customizable in a primary way.

In BU F, where they represent 1/3 of the world market, they have introduced, on the machines that they produce, a lot of software, designed in-house, for remote monitoring through some sensors; they also have optical recognition with software designed in-house. They have introduced glasses for augmented reality. They produce small 4-axis anthropomorphic robots. They have developed a control room and a Help Desk. Where they are backwards is on the Big Data Analytic of the machines already installed but have a project that in the last two years introduces an evolved data collection sensor on all volume products. In his view, customer services are in fact the future.

In BU M, where they are among the top 3 in the world competing with USA and Germany, they have introduced the ability to manage Cloud data. Their systems can, via the cloud, start from a TACof the patient’s dental arch, then build a 3D model of it, send the model to laboratories for the production of parts and prostheses, etc. They are also entering the maxillofacial with a mini TAC. Their image software has been developing for 20 years - working together with the doctors of the University and the Rizzoli hospital - even because of the maximum economic return on the software. Their software can be updated via the Cloud network. In BU I which also includes the construction of Data Center, they have a company that does building automation where software is a critical feature.

In BU S they designed and built the supermarket of the future at the Milan EXPO fair. They used Bluetooth trackers to follow the customer and illustrate the novelties (the beacon for indoor mapping). They can, utilising the same technology, control the opening and closing of refrigerator doors and send the information to the customer's smartphone or tablet that can intervene remotely knowing which of its fridge systems has a problem.

In BU CL, where the main competitor is Philips, they studied the specific spectra of their C-Led lamps together with the University of Bologna, enabling them to grow a greenish edible compound with good organoleptic properties, inside a supermarket developing a "growing" sector that provides freshly produced vegetables. They have a factory that produces digital printing machines: single pass plotter.

In their view, they have a reasonably advanced management of digitising codes and RFID technologies for digitised pallet management. Customer services - via the cloud - are in fact the future.

They have a project that in the last two years introduces an evolved data sensing sensor on all volume products. In his view, customer services are in fact the future.

Employment consequences

In their sphere, they are only positive: the new services are an add-on to the business-as-usual, and therefore they need to hire new skills.

For those who buy their machines, it is true that there are jobs eliminated by automation - for example, cashiers in supermarkets – but it is also true that the supermarket is changing. For instance, the hypermarket is in a strategic crisis; there are no more reasons regarding the number of kilograms of shelves and the capacity in kilograms. Already in the last fair have been presented lighter shelves and totems of interaction with customers. Point-of-sale points are organised into specific thematic areas, where services such as recipes are available – according to mass customisation schemes. Places where the model is no longer one of the bargainings and fleeing but of a place to spend the time pleasantly. Along with this way, new jobs are created.

Competencies and skills

They have a very dire time in finding the necessary skills. They are trying a new strategy: employing so many young people - they started with 10 - who already have a familiarity with the modern digital world. They call it "breeding-ground project". They presented to young people some themes of research and development of innovative solutions. They have listed seven topics: from building automation to customer profiling in digital retailing.

They told the young people that they could try and experiment even by mistake.

They are also working on innovative start-ups with both financial support and support on how to handle a creative business.

There is a need for multi-faceted figures capable of adapting to more roles, for example having technical but also commercial skills. New professional competencies should have the ability to integrate different working processes.

They aim to create a management and development system for the human resource over the next 2 to 3 years. To reach this goal, they plan the use of a dedicated management software, which is formalised and identifies for each of the existing skills - with assessment mechanisms, both hard and soft - and identifying each one's needs for development by providing the tools to achieve it. Such a project requires a change of managers. They are already accustomed to goal-management - MBO - which is right in the short term, but that's not enough. We need to make managers aware of the necessity for them to give and receive feedback to grow the in-house talents we have, to facilitate the in-house growth of competencies wherever possible, and to teach them how to develop their successors. In 2018, we will have the first round.

2.9 SACMI

SACMI is an international group manufacturing machines and complete plants for:

- Ceramics: Design and construction of machines and complete plants for the production of tiles, refractories, extruded products, heavy clay, structural ceramics, sanitaryware, tableware, technical ceramics, carbon anodes and metal forging.
- Packaging (including Beverage and Closures&Containers): Design and construction of machines and complete plants for bottling, labelling, packaging of drinks and liquid foods in plastic and glass containers, machines for PET preforms, plastic and metal caps and plastic containers.
- Food industries: Complete food processing lines for the production of chocolate. These lines incorporate process controllers that ensure output on Sacmi lines is of outstanding quality at all times.
- Automation: Vision systems for the Beverage & Packaging industry, NIR inspection systems for fruit control, olfactory systems, process controllers.
- Service Companies: International shipping and logistics services, technical and technological services for manufacturing companies, administrative services.

SACMI has 1.084 employees in the main plant and 4.180 in the group; deployed on 30 countries (Italy included); the value of production is 931.790.367 euro; EBITDA is 156.000.000 euro; net income is 31.109.825; net equity is 621.000.000 euro.

Interviews with managers

Industry 4.0 is a name invented by the German Industries to indicate something they have been doing for decades: the supervisor. These are software that in the machines they were selling was already able to use sensors to collect data on the operation of the machines. They used it to study the degradation of machines, with a team of maintenance engineers, to plan scheduled maintenance. The German Industries use it as a competitive tool against the Chinese, in fact, at the last world fair, the Chinese were already able to do the same. Today, sensors are more evolved, but evolution is not a "break", while the real innovation is the business model. Competition is also played on selling machines only at their cost of production and recovering margins on the services the digitised machine allows; not by chance, the post-sales numbers are almost equal to those of the machines. This business model requires strong economic and financial shoulders.

The Smart Factory

Their machines are all digital: those for tool making are organized in robotic lines. The design know-how is all in-house, external studies are used to complete the work. All CAD design is a 3D software. They use rapid plastic prototyping and use sintering processes.

The Big Data Analytical is being developed. Collaborative Robots are not foreseen.

Smart products

The number of sensors, their complexity and ability to communicate with each other has increased, and we have been coping with the technology of the supervisor. We have accelerated already, since the last budget, by investing with our own money and looking for other resources. The hardest part is that of human resources. Examples of new possibilities: in wine bottling machines the use of electronic noses, which they have for many years and which also use in the landfill industry. Electronic noses are not very sensitive but sufficient to control carbon dioxide content and either intervene with actuators or warn an operator when the material is not in compliance. On tile machines, there are other applications - digital decoration machines that deposit ink on the tile with a digital print form - but the concept is always the same.

It's about selling top-of-the-range machines to the customer and providing them with new services.

Smart Services

They are mostly process and machine control services, but they are capable if coupled with feedback mechanisms to increase overall efficiency.

To do this, they need to equip themselves both in data analysis – Big Data analytics – and in creating an organisation that can serve customers 7/24.They are trying to develop the Big Data analytics in-house. For a 7/24 call centre, there is a problem of organisation and cultural orientation. It takes people working round-the-clock, and they think they will do it by using their resources in other countries – he answers who he is at work – and stretching their working time a bit. Their machines can also run unattended H24 – just one worker for a 300-meter line, made up of many machines. In 1985 there was one person per machine, on each line, now the ratio is 1 to 10, in the future one can assume a much higher ratio. Occupational effects for customers have already been absorbed during the crisis.

The use of customer data can be a matter of litigation - the property of the data is customer - but there is also the reverse. There are companies that are selling supervisors, i.e. software to install on our machines and we disagree.

Supply Chain

They have a significant supply chain - around 300-400 million years turnover - but the most complicated pieces make them inside.

Competencies and Skills

Finding workers is complicated. Their fundamental relationship is with the Alberghetti Technical Institute of Imola: over 1,100 employees 60% comes from the Technical Institute; there are then 150 engineers coming from the University of Bologna. For them, therefore, the quality of training is essential, and for this reason, they support the Alberghetti from a technological point of view: they donated a CAD classroom with 32 stations, with machines and software the same as those they use. In times of growth, the number of people provided by the school system is insufficient. If one looks at the axis of Via Emilia between Bologna and Imola there are three major mechanical groups: Coesia 1.5 billion; Sacmi, 1.4; There is 1.1. These groups alone absorb a significant share of graduates and technical experts.

To select them, they use the internships, and the typical path is: 3 months interim followed by a fixed-term contract or apprenticeship from 24 to 36 months, then almost all are stabilised. There is not a production characterised by recurring peaks, and therefore a stable staff is needed; if you exceptionally have peaks, then you decentralise the work outdoors. Business seniority is rewarded, such as the supplementary pension after ten years. The presence of a Welfare Company system helps in recruiting young people. Internal training, apart from English and accident prevention, is highly developed and covers employees, customers, and suppliers. There are training classrooms, but also e-learning forms - since 2007 - through a commercial portal where you can see the machines and get trained on how to use them. The most promising employees are also sent to university courses - e.g. Bocconi for managerial training - or at Ambrosetti courses. They consider the use of immersive reality - the glasses - more a commercial spot than something that is needed.

Interviews with workers

Recruitment, Training, careers and assessment

The interviewees think that the career depends on the judgment of the superiors, a lot and that there are preferential career paths. The selection is made responsible using annual evaluation forms. Proactivity, flexibility and availability count. There are personal bonuses. The work is elaborate both in the workshop and in the offices, especially in the technical departments. People reach the maximum career in 10-12 years. The initial period includes the presence of a tutor who is an experienced worker. The tutoring in the technical office is up to two years. The new employees are routed along a path throughout the workshop to familiarise themselves with the work. Sacmi invests in training, also on communication.

Work Organisation

In the assembly department, they work in groups almost spontaneously since it is nearly impossible to mount, test and disassemble these machines alone.

Technology and Industry 4.0

The most informed are the designers and those who have interactions with customers. Designers are already working on new automation systems for the machines they sell. The new automation systems, which require the use of more commercial operating systems, modify the possibilities to collect and transmit information, allowing both preventive diagnostics and improving the human-machine interface (HDI), making it more ergonomic. Some of them have made courses in cognitive ergonomics and give them conceptual input to design. In the company now there are cross-cutting centres of competence which make available both shared files and the possibility of involving them directly. On technologies of connectivity Sacmi is starting soon, but for now, there is still substance laying, ideas are still clarifying. Their competitors are more or less at their level. The trade fairs, the one they are involved is in Rimini, allow you to check where you are compared to the competitors. Automation is changing. There will be higher efficiency, more easily connected machines and data transfer from the machine to the data centre. The new automation line is in continuity with their tradition of interlacing machines, for instance on the machine lines of the closure. The interlacing was done in the past through a device called the ”supervisor”. Now the role of master of the line is played by one or two machines; working on these you can start the whole line, but each machine has a PLC. With the new machines, the intelligence is only on the master machine.

At the moment only a few customers, those who bought the supervisor, can collect information at a distance. Some customers are very careful to allow data collection; they consider the data a value. The most advanced customers - Europe, North America - are interested in these technological developments. The collected data concern, in fact, the efficiency of their machines and the possibility of predictive diagnoses. In fact, the most prominent customers have companies with a somewhat high level of automation.

In the production cycle, SACMI is starting to use German machine tools with already remote connectivity with the supplier who can intervene for restoration and diagnosis.

They already have advanced optical recognition systems, and on-demand digital printing forms.

They use SAP; they have CAD / CAM technologies.

Overtime and work on Saturdays are exceptions for workers, while the extraordinary is standard for clerical workers. Work pace depends on the technologies in use. There is a significant corporate investment in training.

Technologies influence work pace. If you work on machines that can operate unattended, says an interviewed, those work overnight, and when you return in the morning, you have to run to disassemble, store the machined parts, and re-tool up the machine. Only mid-morning you catch up with the schedule. Besides, you have anxiety problems because while you are at home, you wonder if you did or did not do a given operation, if you did it well otherwise you can split the machine, and so on.

The situation is different for designers. They usually produce standard production where work pace are given by the number of changes required. Today they are very busy on new machines. The overtime is generally from one hour to one hour and a half a day; working on Saturdays is rare and only in the morning.

The invasiveness of technology in private life depends on the individual, says a clerical worker; he prefers to know if there is a problem immediately and he always has the computer and the phone with him. He considers technology as an aide, but he is not anxious. There are those who have the opposite reaction. He would like to work from home (teleworking).

The company invest in both professional and language training and security. For example, last year the update on the new machinery directive. Specific vocational training requirements can also be asked.

Industrial relations and Trade Unions

Industrial relations are considered positive. The judgment on the company representatives of the trade unions is fine; the older interviewed are worried about the attitude of young people towards the trade union. In their opinion, young people do not understand their importance. There are conflicting judgments on the national and local trade unions.

2.10 BOSCH – BARI

From Bosch web site:

> The Diesel Systems division at Bosch develops, manufactures and applies diesel systems which contribute towards making vehicles more efficient and more economical. As the world's leading manufacturer of diesel injection systems, Bosch provides for every customer and vehicle application the appropriate system.
>
> Areas of operations:
>
> - Fuel Injection Equipment
> - Exhaust Gas Management
> - Engine Control Units and Sensors
> - Alternative drive concepts
> - Engineering Services
>
> Modern fuel injection equipment such as Common Rail Systems and Exhaust Gas Treatment systems are the basis of the advanced diesel engine.
>
> Bosch Diesel Systems provides a comprehensive product portfolio from single components to overall systems, for the smallest to the largest engine application.
>
> The Bari Bosch site, made up of Diesel Common Rail injection system components manufacturing plant (Tecnologie Diesel S.p.A.) and Research & Development Center for Common Rail projects (Centro Studi Componenti per Veicoli S.p.A.), is one of the most important companies in Southern Italy area.
>
> Bari Bosch site has played a key role in the Common Rail history which has changed diesel engine. The first prototype of Common Rail high-pressure pump, indeed, was designed in Bari in 1988 and further developed and industrialized up to series production, which has reached 35 million pieces in 2015.

The Bari plant – funded in the late Nineties - is an operational unit of the Diesel Systems division, which itself is part of the Bosch Group's Mobility Solutions business sector. Bari plant produces common-rail diesel injections pumps. It is the largest Bosch entity in Italy, as well as the largest manufacturing facility for automotive components in Southern Italy.

The Bari plant was opened in 1998, and it employs about 1900 workers. It produced three models of common-rail diesel injections pumps – CP1, CP3 e CP1H – nowadays only CP1H. In 1993, the first prototype of a common rail high-pressure pump was designed and prototyped by the engineer Ricco in the University of Bari.

Since 1998, the Bari plant has changed its production relocating to Turkey the production of brake systems and calipers before produced in the Bari plant. The management has decided to concentrate in the Bari plant the production of high value-added activities – such as mechanical machining on the pump body part and on the key components tested with the pumping elements – relocating abroad the non-strategic productions. Indeed, some components such as screws and assembly components are purchased from suppliers. In the Bari plant, two main activities are developed: on the one hand, mechanical machining on the cast iron block is performed; on the other hand, there are production lines of the components and the related assembly lines.

The main buyers are Renault, Peugeot, Fiat, and Iveco. The organisation of production follows a specific model of management based on the so-called BPS – Bosch Production System – that is highly inspired by the Toyota model (lean production systems). There is a high level of coordination and integration with clients and suppliers that can send on a real-time basis a specific order that will be immediately taken into account by the production lines – this is an experimental design, only active on the IVECO productions (bit to order). The Kanban organisation of logistics and production is integrated with the SAP software allowing for a full integration of operations in the factory. The daily production of the Bari plant is around 9000 common-rail diesel injections pumps on four main production lines – all CP1H. The production is highly standardized with the only exemption of customisation concerning the final product.

Interviews with managers

The Bosch group is both producer and provider of Industry 4.0 technologies. The Bari plant has already started with the implementation of ad-hoc project related to data acquisition, machine learning, and artificial intelligence. Two times per week, the plant coordinator for the implementation of Industry 4.0 discusses with the other coordinators of Bosch plants in Europe and the world the implementation of industry 4.0 projects. There is an increasing attention toward the full implementation of the Manufacturing Execution Systems (MES) helping in tracking and gathering accurate, real-time data about the complete production cycle, beginning with order release until the product delivery stage for finished goods. Therefore, the main idea of the Bosch group is to create a dedicated Bosch cloud containing all data which will be available upon request through a dedicated app. The application of Industry 4.0 in the Bosch Bari plant should follow some major points:

1. Additive machine evolution: machines are adapted to the introduction of some technologies more than fully substituted by new machines;

2. Industry 4.0 projects financed by Bosch are those having a short-term economic return, investment-saving evaluation on a maximum time-span of 2 years;
3. The elimination of low value-added activities.

Among the Industry 4.0 projects financed in the last years, there are:

1. *ActiveCockpit – Interactive communication platform for the manufacturing industry*
   The real-time collection, processing and visualization of all relevant data of a manufacturing facility for the exchange of information between people, machines and production processes on the shop floor. It is an interactive software for the diagnosis and optimisation of machines and processes and disorder management. It is a browser-based Internet standard and open to third-party applications allowing easy connection to back-end systems (MES / ERP).
2. *Machine monitoring*
   Assembly of sensors on the machines to collect data. Machines communicate directly to the main server in case of machine block, while the operator should introduce on a dedicated iPad the cause of the machine block. The system allows a real-time data collection, however, it does not permit a self-diagnostic nor the communication among machines located in different factories.
3. *Overview of the production across Bosch factories through the Manufacturing Execution Systems (MES)*
   The MES collects data about product genealogy, performance, traceability, material management and work in progress (WIP) and other plant activities as they occur.
4. *Digital supermarket and interactive milk run*
   A round trip that facilitates either distribution or collection through an internal GPS that localises the logistic operator and allows saving time in collecting or delivering materials to each production unit.

Interviews with workers

Workers have the perception that Industry 4.0 projects introduced in the Bari plant do not improve the quality and organisation of their job. On the one hand, there is an increasing suspicion that the digital supermarket project as well as the milk run new functions will increase the monitoring of their activities and control on their work. The GPS system on the milk run has increased the possibilities of remote control of workers, mostly the ones employed in logistics.

Quality check and machine tools

High quantities of production waste and defective pieces blocked due to a management decision to decrease the number of checks during production from one piece every 30 to one piece every 60.

An increase in volumes produced but the reduction in the number of staff; it leads to a general reallocation of workers between departments.

The use of machine tools is perceived as more comfortable, even if the operator has acquired new responsibility regarding machine monitoring.

Implementation of Ratio-projects

Bosch does not invest in new machines, but it tries to improve the existing ones optimising working times. Many workers complain about the so-called just-in-time production process that is in reality not adequate to fulfil the lean production. Indeed, along with production lines there exist numerous small stocks that are used in case of machine blocks. The Bosch monitoring system is not adequate because most of the machines are quite old and should be substituted. There is not so much space in the factory; it leads to restricted internal traffic.

Workers interviewed admit an overall improvement of working conditions. However, they report an increase in the pace of work and stress related to the management of more than one machine. The work is perceived as lighter physically but more psychologically stressful.

The union fears that the introduction of new technologies can lead to greater remote control of workers to gather more information on working times.

2.11 CAREL – BRUGINE (PD)

Production and main customers

Carel produces temperature monitoring solutions for hotels, hospitals, restaurants, shopping moles, ICT Firms, etc.

Its main customers are big OEM manufacturers in the conditioning, supermarket refrigeration and humidification. Formerly, many customers were Italian companies, while currently they are mainly German: Rittal, WOLF, Kampmann. The Italian customers left are Clima Veneta, Arenk and, in the retail sector, Costan Eptan Refrigeration.

Each market is assisted by a dedicated Business Unit taking care of products specifications, i.e. both personalisation of existing ones and design of new products. Besides these BUs, common platforms have been introduced to design new cross-cutting products.

All BUs cooperate with the R&D and Product Development departments, i.e. 130 employees developing both new products and programming tools, including software).

As regards Carel range of products, an evolution took place in recent years: formerly, Carel used to realise control devices only, while currently it produces the whole system of control and supervision for energy efficiency. Now Carel does not merely provide products, but a fully-fledged climate service.

Control devices include electronic valves, and inverters for fans and compressors – Carel draft agreements with compressors manufacturers. As regards inverters, they were formerly purchased and resold, while now they are produced by Carel itself; the same holds for valves. These reorganisation processes took place in the last 8 years, aiming at providing a more and more complete system.

Presence abroad and externalisations

Carel's presence abroad is significant in Croatia, USA, China (270 direct employees; in recent years, Carel has started designing the whole controls chain), Brasil (due to the presence of duties).

In the case of China, the idea is that of serving Asian markets, in order to be close to local markets such as Thailand, South Korea and Australia.

While these are distant markets, the Workers Council (WC, hereinafter) is worried about Carel Adriatica – Croatia – which also takes care of new product lines.

There also are many trading arms abroad; the network is very pervasive and consists of branches which formerly were mere subsidiaries.

From the point of view of externalisations, the opposite situation seems to have occurred: as described above, some productions – such as inverters – were internalised, rather than externalised. Contractors, therefore, play a marginal role. Externalisations only concerned the stamping of plastic components and small products, packaging, and the warehouse – whose management was awarded to a company from Treviso.

The Company's plan

Industry 4.0 technology which Carel considers useful for its development is IoT: the company progressively went from producing components to providing solutions: customers do not only ask for a product, but rather for a set of devices that, put together and in communication with each other, can provide a complete solution, e.g. to the problem of energy saving and efficiency.

A connectivity platform already exists, which can be reached remotely via smartphones, apps, etc. However, IoT will make it possible to introduce machines communicating with each other, as well as the collection and elaboration of big data.

More specifically, investments will concern a software for machine-to-machine (M2M) connection both in the entire plant and among different plants of the same Company. The system is connected to a server that collects all information and manages production processes.

By connecting all production lines, the software can grant the proper implementation of tasks; any modification of productive parameters of a single machine are immediately communicated to all other machines and lines, but also to all other plants, in Italy and abroad.

This is a kind of machine learning. On a daily basis, in fact, the necessity arises to update and calibrate products and processes parameters (electronical, mechanical, chemical, physical, ecc.) When a worker suggests the modification of some operating parameters, the modification has to be validated by a dedicated office: at this stage, the modified parameter is shared by all machines.

The procedure works as follows. The machine whose parameter was modified by the worker – after the dedicated office certificated it – is connected to a computerised system which is in turn connected to a server which collects information. The line following the one where the modification was originally implemented decides to implement it as well, which happens immediately and without any intervention by the workers. The same happens for all following lines.

The same mechanism works for other plants, even when located abroad: a modification implemented by a plant is incorporated by the others.

This happens thanks to connectivity, which allows to share information with servers located in other countries. Production programs are therefore synchronised worldwide.

The validation certificate is uploaded to a repository, on which machines automatically draw manufacturing scripts, and hence also scripts modified following the procedure described above.

At the time being, impacts on employment have not been estimated, but according to the management they will be positive: new needs will emerge, and hence specific training for the development of new skills will be implemented. However, workers representatives are concerned about possible employment reductions, since the new Croatian plant went in a very short time from 18 to 76 employees; at the same time, temporary workers employed in Padova were not confirmed.

The production process

Some machines are in charge of assembling several parts and components. In order to avoid mistakes by workers, Carel takes advantage of informatic systems, such as MES, to recognise components to be installed. Workers use optical readers to recognise the code associated with each particular production order. If the system recognises the component as the correct one, it is installed. Otherwise, in presence of an error, the machine can single it out and suggest how to correct it.

This system works for every production stage, and for each and every machine.

The system controls both the whole production process and every single machine; but most of all it can control workers performance.

Moreover, productive lines must be completely programmable. Each operation has to be checked via a specific procedure. A standard is defined for each process, describing all production procedures. Standards are then collected into the standard book, which is an industrial secret.

The first stage of the process is the laying of the welding material on the printed circuit, during which control systems check whether the quantity of welding material is correct.

The following stage is the placement of components on the welding material itself. The assembling machine is checked via an optical system which verifies that every component is in the correct place.

The welding process continues in the oven, where process controls has been introduced, consisting of a mixture of hardware and software, which monitors all circuits passing through the oven itself, and which rates each welding procedure.

All processes collect data through a series of steps:

Step 1): data are visible on a monitor;
Step 2): the effects generated by process controls are verified;
Step 3): all data (about machines functioning, quality parameters, operation times, etc.) are synchronised.

The company's goal is to plan and manage the entire production process in real time: starting from a piece of information given to the system about the availability of human and material resources, the system itself reacts by planning the customers' orders fulfilment (self-levelling and self-reacting system).

MES translates information taken from Oracle (planning system) into work-orders for production lines with a daily schedule. Moreover, MES monitors the process of production, identifying the current stage and specific operation in progress and immediately detecting any problem. Moreover, it tracks what every single worker does in every single moment. In other words, operation times are established by Oracle and managed by MES: each worker, with an optical scanner or a touch screen PC, reads a bar code which initialises the corresponding operation.

Thanks to these systems, Carel can trace the production process as a whole: from the inputs obtained by suppliers to the final product given to a customer.

Batch manufacturing has been abandoned, in favour of the production of single pieces on specific order by the customer – a strategy which allows avoiding [è giusto in entrambi I modi] inventory costs. Orders are placed online and passed on to Oracle, a management system, and then to the logistic office. The latter verifies production capacity, i.e. the availability of material and human resources, etc. If requirements are complied with, Oracle confirms order fulfilment date; otherwise, it looks for an alternative date and then confirms it with the customer.

In their daily activities, workers interact with MES, which monitors production progress by singling out the stage the whole production cycle and the single production activity are in. Moreover, it detects possible problems and records the activities carried out by any worker at any time – e.g., whether she is working, or is on break, or a machine break occurred, etc.

Integration with logistics

Again on the subject of integration, Carel realised a full interconnection between internal logistics (warehouse system) and the ICT systems of express couriers such as DHL, UPS, TNT, FEDEX, etc.

When a worker completed the final packaging in the warehouse, and the order is ready for shipment, she interacts with the ICT system of the courier, which provides shipping cost and tracking number, and prints the corresponding shipping note. Formerly, these steps were carried out by several workers in successive stages. Currently, this information about shipping, including the tracking number, are automatically sent to the customer via Oracle, in the same way as Amazon does.

Workers participation

As regards workers participation, according to the WC "the company has many ideas, but they don't share them with us."

"The new integration contract made a relevant step, because, after years, we managed to put in writing that they must give us information every year. We achieved it last year. However, this is the typical north-eastern family business."

"The new organisation of work suddenly came from the top and was learnt by workers only gradually. Moreover, there is no valorisation of workers' knowledge. Line operators have great knowledge, and give advice on 5S, which are often diminished. The company thinks to be entitled to everything, nothing is recognised."

2.12 COSTAN – BELLUNO

Costan (as part of Eptan Group) produces professional refrigeration systems. The main applications concern commercial distribution and air conditioning of large spaces. Its investments in

Industry 4.0 technologies aim at implementing:

- IoT, to connect machines and plants that can communicate with human beings;
- Big Data: to develop new product and process strategies;
- 3D printing for prototypes but, in the future, also for spare parts;
- digitalisation of the entire production process, to improve flexibility and to give immediate answers to customer needs;
- new robots to support human work.

Automation in departments

Currently, the doors construction and metal sheeting departments are the most automated. For example, in the metal sheeting department, the production sequence goes as follows:

- customers send orders
- SAP computes input requirements for their realisation
- MRP verifies availability of materials and indicates missing inputs;
- a software called JETCAM generates information for each machine (CAM);
- NICIM schedules production.

The system is fully connected and provides machines with information and production orders.

The machines operating on steel work 7 days, 24 hours, even on Saturdays and Sundays when the factory is closed. In this way, on Monday morning workers find the components ready to be used. When the plant is closed, an automatic warehouse provides inputs to machines and, after production, stores them.

A similar degree of automation, though slightly smaller, exists in the surface coating department: everyday, a list of colours to be realised is made available; for each colour, the list of pieces to be varnished is provided. Hence, each piece is associated to a specific colour, and the coating sequence is defined. The glassmaker department is also managed by a software which tells each machine what to do and in which order, but the department is not totally and automatically connected: "the software tells the machine to cut the glass. Then we have to move the glass to another machine [...] the software provides the sequence and the corresponding manufacturing scripts, but there is more dexterity between different stages." the glassmaker department is organised as a series of machines which follow a flow, but they are physically separated and workers load machines and load the appropriate manufacturing scripts."

Supply and other plants networks

Also in the case of Costan it is important to stress the importance of networks, both with suppliers and other plants of the Group. Costan purchases the great majority of raw materials from external suppliers: coils (for metal sheets), glass, evaporators, all spare parts, metalware, electric cables, electric components (e.g. thermostats and transformers); isocyanate and polyols for skimming, compressors, collectors, etc. While iron and metal sheets are purchased, almost all the processing is carried out within the company, from building the structures to surface coating, etc.

Only when excessive workloads slow down the building of structures, some parts are purchased from external suppliers.

With closer suppliers, a kanban system does exist: an operator presses a button and automatically a supplier receives an order. For example, when steel is needed, an operator presses a button and steel suppliers must deliver it within three days.

A similar system connects Costan plants, not only the four of them in Italy, but also those located in France, UK, Sweden, Denmark, etc (but also in Argentina, Turchia, Colombia, Cina, Thailandia). Each plant is specialised in a specific production, and some of them provide the others with parts components. For example, the machine producing the shelf of the fridge is located in France, and it produces shelves for all other plants via kanban system.

The distribution of orders among different plants is very important: even if each plant is specialised in a specific production, some of them (Belluno, France, UK) produce the same kind of units. Hence, if one plant is overloaded, a part of its production volume is shifted elsewhere. The nervous system that distributes this information is SAP.

Orders acquisition and production organisation

Planning meetings are organised each Friday to collect acquired orders and plan production sequence.

Hence, production is planned weekly, and the management decides how to allocate it to the different lines. Orders come from the big names of commercial distribution: Conad, LIDL, Bennet; also from abroad: Saudi Arabia, Russia, etc.

The industrialisation technical office monitors the daily workload and allocates it to the different lines. Hence, work orders are printed every day and distributed to the various departments. The first stage is the preparation of metal sheets. Workers provide machines with manufacturing instructions via on board computers.

In the second stage of metal sheet processing, the various pieces enter FinPower machines which cut them. Almost all these machines involve the use of a laser; they cut by the required shape, drill holes.

The following stage is folding, carried out by a programmable numerical control bending unit: workers upload scripts, and the machine automatically carries out planned tasks.

The Finpower warehouse is provided with an automatic trolley which collects and stores processed metal sheets, without human intervention.

Metal sheets then go to the injection department, where top and basin are assembled and then prepared for the following stage. Preparation consists of the positioning of plugs, styrofoams, tapes, edgings. This stage is manual and is carried out with the help of screwdrivers, tape dispensers, drills, grinders.

Injection is carried out by programmed machines; each basin has a specific magnitude, associated to a specific code. The code is submitted to the machine, providing information on the exact point where the machine has to inject for skimming. After skimming, a trolley conveys the processed piece to the line. Here, the first stage is assembling the structure.

There are different ways of providing the lines with the required components, according to the kind of components themselves. Semi-processed components are continuously supplied by a trolley; other components are supplied via kanban system, while dispensers of smaller components such as metalware are always full. With the 5S system, workers should never their work station; however, sometimes the supply system does not work properly.

After fitting the structure, the refrigeration unit goes along the line to the following stages. All missing parts are assembled: shelves, compartments, electrical parts (provided by an internal department), evaporators, etc.

The electrical parts department is a separate unit. Part of this manufacturing stage is carried out directly along the production line, but the great majority of the electrical panel is assembled in this specific department. Here, a new system has been introduced: a dedicated warehouse supplies all components necessary to assemble the panel. Components, together with the printed description of the sequence to be realised, are supplied by trolleys. Sequence descriptions also include specific requirements; workers, at their workstation, can refer to an instruction manual specifying all the single steps to be done according to the corresponding the sequence.

Components to be fitted to the panel are switchboards, controllers, converters, thermostats, cables. Everything is provided in specific kits.

Normally, the departments responsible for preparing parts and components for production lines work a day early. The numbered sequence of processing stages to be carried out is given by printed worksheets indicating daily workload: workers label each electrical panel with a number corresponding to the customer order and a code. Hence, each piece is flagged with the indication of the specific worker who carried out operations.

Testing allows to single out any possible problem, and the stage at which it arose.

The units supplying the lines are the glass, metal sheeting, skimming and electrical departments, together with surface coating; assembly takes place along the line.

These operations, at the time being, are only connected with printed sheets and labels.

At the end of the line the product is completely equipped, also with doors which are almost entirely produced by robots in a dedicated department.

Testing is done by machines with sensors. A follow-up testing is given by the so-called “timeliness parameter”.

Technological innovations along the lines are described positively. More specifically, these innovations are electrical screwdrivers, suction cup manipulators, tilters, lighter structures: these new tools and equipment improved the quality of work.

Moreover, a new department for the production of doors has been introduced which is almost completely automated. There are only two workers with the task of assisting the robots managed by a control room.

2.13 MIDAC – SOAVE VERONESE (VR)

Midac produces batteries for automotive and industrial applications and for TLC equipments.

Since 2007, it is applying the Toyota Production System, whose principles are:

- continuos improvement (kaizen) to grant technological innovation and productivity maximisation;

- just-in-time – i.e. producing or acquiring only the exact amount of inputs which are required at each specific point in time; this implies balancing and fine-tuning the productive chain starting from market demand and planning;
- creating a smooth workflow characterised by both flexibility and strong coordination of all its different parts: suppliers, manufacturing, logistics, etc.;
- monitoring quality in every production stage.

By such a Toyotist pattern, Midac intends to realise investments in industry 4.0, and more specifically to:

- computerise production processes, in particular the sequence and progress of each production stage, with ICT tools, in order to have control in real time over all steps (productive lines are monitored to collect data about start and end of operations);
- install a Programmable Logic Computer (PLC) on all machineries in the plant, to monitor in real time produced output, quality, and execution time; moreover, the system will be able to communicate any problem to maintenance services, through monitors and smartphones, to reduce recovery time;
- introduce five new robots to perform hard and monotonous tasks;
- provide batteries with devices for remote control.

Midac is at the centre of a complex network of suppliers of several intermediate components: lead, boxes, covers, sulphuric acid, steel, plugs etc. In order to optimize the production times, all these supplies must be carefully synchronised, since batteries are produced only upon the arrival of orders by carmakers.

Thus, production planning must be defined and realised just-in-time. In particular, the charging of batteries needs to be carefully fine-tuned, since they must be delivered exactly when carmakers are going to assemble them, and at that moment they have to be fully charged.

Moreover, when carmakers' aftermarket delivers orders for batteries, Midac must comply in real time. The crucial role of logistics is therefore absolutely clear.

Interview with RSU (WC)

Currently, machines are programmed and partially automated, but workers have to load and unload them, i.e. there is no full automation of the whole production process.

Organisational innovation in the production process

From a general point of view, innovations introduced were:

- organisational (in particular, as regards the management of orders, which are acquired by the sales network and put into the system to be processed by the technical office, which in its turn deliver them to the corresponding department);
- technological ("currently, robots do the heavy work in our place, but they did not cause the loss of jobs, [...] because workers in charge of those tasks have been moved").

The management system is still SAP, while a MES is being developed. Documents management is done with Autodesk, development with inventor, design with CAD and AutoCAD.

Orders are acquired by the sales office, after a market campaign in Europe, US, Australia.

When an order is manufactured, the system (SAP) allows for each department to know exactly what they have to do. Traction and finishing departments take advantage of the management system to print schemes since each traction battery has a specific lay-out and manufacturing method.

In the first plant, after an order is acquired a code is created; the aftermarket department, on the contrary, makes use of the applications directory and hence the person in charge has to compare data associated to the order with those provided for by the directory.

At this point, the Planning departments weekly define working plans for traction batteries and stationary devices; in the other departments, planning depends on orders frequency.

The Planning department delivers orders to productions departments via email or on paper. The management of the order is passed on to the head of the line who self-organises her activity. "For this reason, workers are taught all production stages and all the things to be done. [...] In this way, even if the head of the line is not there, workers know what to do.")

Industry 4.0 in the product

Midac takes advantage, for the production of some batteries, of simulation and virtualisation systems: 3D development is used to simulate their size and functions. The company also takes advantage of a diagnosis and predictive maintenance system, i.e. a module placed above the battery, which can control everything (for instance, the temperature during charging) which can be accessed remotely in presence of a specific set-up. Normally, these batteries are mounted on AGVs: "customers need to know when the batteries are out of charge, hence the module is equipped with a connection interface which signals when batteries need to be recharged."

The production cycle

When an order is acquired, the first stage is the definition of plate models for the manufacturing of batteries. Production starts with rolls coming out from a numerical control MCN rolling mill. The following stage is performed by a NC machine manufacturing the grid mesh; the semi-processed material is then sent to the mixture department where a spreading machine is at work.

Mixtures are prepared by automated machines according to data transmitted electronically: the dedicated worker is only in charge of pressing buttons. When operations are concluded, the machine makes a warning sound. There are two machines, one on top of the other. The one located below is manually loaded by workers with plates. At the same time, the machine located above prepares the mixture on the basis of scripts, already loaded to the machine itself, providing for data on mixture composition. There also is a different kind of mixture whose preparation is semi-automated: the dedicated worker manually enters data according to the kind of mixture to be obtained.

When plates are loaded, the machine spreading the mixture is programmed.

The cycle time depends on the chemical characteristics of the different mixtures, and spreading times depend on the quantity to be spread. The company took the timing of a complete preparation process and standardised them. However, there is a degree of flexibility directly concerning the worker loading flat iron. At the end of the process, flat irons are unloaded by a robot.

Hence, a worker loads the machine which returns smeared iron going to a drying chamber. After drying, flat irons are piled in packages, each containing 15/20 pieces, by a robot. Rooms for further automation, as stated above, are present in the loading stage; here, Industry 4.0 investments are still possible. Besides automation, Industry 4.0 will make it possible for the company to have real-time data on machines functioning.

In this respect, the company is already trying some tests on a machine: AD5, producing positive tubular plates: thanks to a tracking and control system, when returning the plate, the machine can assess whether it was processed correctly.

The following stage is performed by a divider, dividing the plates according to the poles (positive or negative). After that, plates enter a drying room from where they reach an area where a robot piles and stores them on 'ripening' shelves. The latter are part of a warehouse which works according to the loaded/empty system; the anbam system is applied to all semi-processed materials.

When plates are processed, they go to a machine in charge of packaging, isolating every single plate from the others. This is done manually by workers or by a COS machine.

At a later time, plates are welded connected positive and negative poles and equipped with a lid. These tasks are performed by machines linked by an automated conveyor belt.

The warehouses supplying these production lines are automated: the machines themselves take the required components.

The following stage is bonding, which is done in two workstations where dedicated sensors activate machines. Afterwards, terminal poles are closed. The quality of the complete battery is ensured by a sequence of tests and controls done by specific machines providing batteries with serial numbers (corresponding to day, month, year and shift). In this way, traceability is also ensured.

Finally, batteries are charged; charging times depend on the kind of battery.

2.14 FONDERIE ZANARDI – MINERBE (VR)

This company has changed its business model: before the crisis the company filled the market with its products; now the perspective is inverted, with customers demanding specific products. The firm wants to get the customer 'inside' the company; customer's needs lead company's decisions.

Within this framework, technological innovation plays a fundamental role to build an integrated process that starts from iron foundries and integrate other industrial processes. The firm's strategy is to utilize all technologies that are useful to provide the customer with a full service.

The Zanardi Foundries, trough melting of cast iron and other materials, produce half-finished items and blanks. The aim of the business plan is to invest in downstream processing, after the melting.

The plant already involves some form of automation, but it lacks ICT and other technological requirements.

Investments concern new machines networking with robots. The company will have to study where to locate the robot, how to connect to networks, how to exploit big data, how to introduce processes control systems. Software will be used that supports and plans processes, collects data and that – autonomously – trough an ongoing learning mechanism will be able to give immediate answers to production lines. From the point of view of infrastructures, RF (RFID) needs to be reinforced and optical fibre to be introduced. All these elements will be integrated into the plant system.

Changes will concern software too, with the introduction of MES to support the control, maintenance and transport activities, and communicate with costumers and suppliers through specific interfaces. MES will be used for production planning, data management, process control, maintenances management, etc., and will be provided with an advanced database. The company already collects a huge amount of data, and hence tools are needed to link and process them.

Additional investment will concern new machinery, especially for downstream mechanical processing.

When the company announced its investment plan, the workers' council felt reassured because "this means that the firm wants to continue the production after the crisis"; however, the concern does exist of having to learn how to work with new machines and new technologies. Currently, labour is still mainly manual, and the average age of workers is relatively high: there is no guarantee this process will be smooth.

The production process

The design is passed to the prototypes department, that produces all the models to create the stirrups. A core is necessary to create an empty space inside the piece to be realised; the moulding department then sets up the model and realises the stirrup.

Cast iron is created within the three electric melting furnaces and then trickled in the stirrup. There are two semi-automatic overhead moving cranes. The first one is located in the storing materials department, which supplies the furnaces with the materials necessary for the melting process.

The worker in the control room, with a dedicated PC, delivers the order for materials provision to a worker in an upper control room (behind the furnaces, in the storing materials department). The order gets to the PC of the worker in the overhead moving crane control room, who accepts it with a touchscreen monitor.

Hence, the overhead moving crane automatically moves to take the materials. It is a worker who, with a joystick, collects the materials and, by pressing a button, tells the overhead travelling crane to position itself over the furnace materials have to be discharged into.

The casting process is controlled by computers in the upper part of the plant, i.e. close to the casting process itself. After casting the conveyor rail, driven by a PC controlled by the moulding department, takes the stirrup around the designated stations for cooling and de-stirrup. Before the finishing, the piece is put into a rotating barrel, similar to a concrete mixer, to remove excess dirt.

At this point, the piece gets to a station where different parts are manually separated and cleaned from impurities. Finally, a sandblaster, remotely driven by workers via a PC that deals with all its tasks, cleans it again.

The following step is mechanical processing. According to the Management, this is precisely the stage which should be interested by the great majority of Industry 4.0-type investments. A forklift truck with a cargo bed drives the piece to the mechanical processing building.

Here, they are milled and turned. This process involves four kinds of machines: 3 horizontal lathes, 4 vertical lathes, 3 machining centres and 2 robotic units. These are two robots which load and unload pieces on the lathe they are connected to (two more robots are in the deburring department).

At this point, the rough piece can be delivered to the customer, or it can be heat-treated and painted. Three furnaces are devoted to heat-treatment. The piece reaches them on a forklift truck. Workers manually unload the cargo bed into the furnace, and at the end of the treatment load them on a conveyor belt to the washing. Here, workers only have to load and unload and steer the washing process. Pieces are driven to immersion painting by a conveyor rail whose hooks are manually loaded and unloaded by workers.

The cores warehouse is fully automated. When the warehouse runs out of cores, they are replaced by workers in the core-making department manually loading trays and delivering them with a conveyor belt. In the warehouse, the belt is unloaded by an automated machine which takes and stores the trays one by one. All the process is computerised and managed by warehouse workers: after typing the code of the required cores, the machine delivers the corresponding tray which is then loaded on a forklift truck and taken to the moulding department.

An important link does exist between the machinery, and between machinery and remote stations. For example, the casting, overhead, warehouse and moulding equipment can be remotely controlled by a PC which can communicate with them. A company laptop is provided to some selected employees who can remotely connect – from anywhere, and even from home – to the PC, and fix malfunctioning or any other problem.

The overall work program is uploaded to the on-board computer almost any equipment is provided with, while technical files are printed on paper. Any time a worker performs a task, this is digitally saved and associated to a specific serial number; each task can be activated by passing to the computer technical specifications data concerning the piece to be realised and the various processing stages. Of course, each instruction passed is saved and recorded, which allows traceability of the process and of the utilisation of different machines.

During the whole production stages, communications by cellphone take place as well, to allow real-time updates about tasks to perform and exchange of any other useful information about the production process.

As mentioned above, all machines are provided with on-board computers. Some of them are already networked, e.g. the moulding with the casting machines. For example, from the on-board computer of the moulding machine, it is possible to set data specific to the model to be used for casting. A worker is needed to supervise, but instructions are already uploaded and hence networked machines cooperate autonomously.

Deburring and mechanical making machines are networked as well: on-board computers are provided serial codes of pieces to be treated. Specific functions set the start and end time of each task performed, which are then recorded and available to a central department which monitors all activities in real time.

The company employs 207 workers; within two years, 25 of them should retire, and no new hire is planned to replace them, even if 35 jobs were lost in the last two years. This complies with the company strategic project, planning to cope with retirements by making employees multi-purpose workers, i.e. working in multiple departments. It is in this sense that new technologies will be labour saving.

2.15 ABB ITALIA

The activity of ABB Italia is organised in four divisions: Electrification Products; Discrete Automation and Motion; Process Automation; Power Grids for utilities, manufacturing, transports and infrastructures.

ABB is devoting particular attention to Industry 4.0. In its plans, automation must be integrated with data measurement; smart products and devices must become the centre of industrial processes; data generated by smart devices must be collected either directly or through automation systems.

ABB's products are themselves smart devices, machines and plants for digitalised substations; (remote) monitoring of machine function; management of energy-saving projects; smart management of mines; optimisation of transport routes and paths for efficiency and safety; and centralised fleet control. As a consequence, ABB also developed the main elements of Industry 4.0 in services as well, such as remote support for data collection and transmission to the cloud; management of energy consumption; remote control of robots; smart monitoring of frequency converters; and safe cooperation between robots and humans.

Moreover, in ABB plants, production processes are organised according to the basic principles of Industry 4.0. RFID gates register every inbound and outbound shipment. The transportation of components from arrival to storage is done by automatic conveyors and automated guided vehicles (AGVs). Customers' orders can be dealt with even at night, with an automated ordering system that guides customer orders to an automatic assembly line in real time. The automatic production lines also integrate traceability, and each piece produced is uniquely marked. Thanks to automated logistics, ABB implements automated storage, which controls the assembly lines. New orders are generated as stock runs low or a big order is received. The aim is that of reducing the risk of delivery errors to a minimum. A further priority objective is a rapid response through remote monitoring, e.g. of energy production. Production processes are themselves controlled by a monitoring system, which works in real time and indicates equipment malfunctions, reports tests showing causes for rejected pieces, shows inventory levels and generates statistics from production data.

White Collars Productivity

The White Collars Productivity (WCP) project is part of ABB's general plan for the reorganisation of the whole group to save one billion dollars. At the time being, about 80% of white collars employed by ABB are based in western countries, and only 20% in 'low cost' countries; the explicit task is that of reversing this proportion. This operation concerns the reorganisation of ABB's service centres all over the world: Western Europe, USA, China, India, Mexico, Poland and Estonia. Production plants are also located worldwide: Italy, Sweden, Germany, Switzerland, Finland, UK, Spain, France, Norway, Benelux, Poland, Romania, Bulgaria, Czech Republic, Austria, and Estonia just to mention European countries.

The WCP project goes together with the many delocalisations concerning industrial production – which reduced direct costs – and will affect about 2,500 workers. The aim is that of reducing indirect costs such as administrative, planning and legal services. The technological revolution is running over office work, making it possible to reorganise offices which used to operate on a local basis. IT now allows the a creation of common system for the management of all data via global service centres. The new headquarters for Italian corporate services will be Cracovia. These new global service centres will manage IT, accounting, account management, tenders and HR. This is the last stage of corporate services centralisation. Formerly performed in every single plant, they were centralised at the national level (in Dalmine and Sesto San Giovanni, in the case of Italy). After completion of the WCP project, the Italian national headquarters will only compile annual consolidated financial statements and manage some specific customers.

2.16 ABB – DALMINE (BG)

ABB production in the energy sector consists of four divisions: medium-voltage (MV) panels, switches, low-voltage (LV) components, and service. The four divisions are characterised by various degrees of automation and computerisation, where the less automatised one is the latter.

In the last three years, the MV panels division has been the subject of investments which generated significant changes in terms of safety, workers' skills, and working conditions. The most recent trials concerned logistics and material handling.

MES and Automation

In the same years, a new management software system (Manufacturing Execution System – MES) and three conspicuous investments in machinery have been implemented. MES is software able to trace all the components of a panel. Therefore, a workstation equipped with a computer can record all the tasks to be implemented and the components to be fitted on a panel. In this way, it is possible to avoid losing information on the components already mounted on the panel itself.

At the same time, ABB made investments in automation, like panels automatic payload: an automated forklift takes the MV panel from the production line and brings it to the required working area, e.g. for trimming or packaging, where another machine (introduced about one year ago) reads via MES the technical characteristics of the panel and, on the basis of the results, decides upon the kind of packaging which is required and the destination.

The automated system allows mounting on the MV panels all the components which are necessary for its functioning: transformers, switches, protection, etc. The panels are purchased by utilities operating in the energy sector or by private companies and used for power stations, ships, shopping malls, etc. An important part of the organisation of labour and production is the ability of the system to read the data sheets of the different materials to know which component is to be picked up for each specific stage of the production of the panels – which consist of heterogeneous materials.

The transformers are produced in ABB plants in Poland, Czech Republic, and Finland. MES can monitor the whole process, from the shipment of a component to its installation and future operation. By way of example, a transformer shipped from Poland to Bergamo is associated with an acceptance certificate. As the component is unloaded in Bergamo, MES reads the matriculation number, goes back to the production plant, connects to the corresponding information system, tracks the acceptance certificate and imports it to the plant's information system. Formerly, this procedure performed was by hand by two employees who have now been relocated to other tasks – one of them now deals with maintenance. For the time being, this system is implemented in Bergamo only but could be extended to the whole group, saving time and, most of all, staff.

New investments also allow internalising production stages which were formerly performed by suppliers. Until recently, carpentry was purchased from an external supplier. Now a machine (Prima Power) has been installed that produces carpentry inside ABB. Prima Power is a 50-meter machine which develops carpentry with the aid of ABB robots that transport the sheet metals. All these machines communicate with each other thanks to software which was developed by Prima Power but is further programmed by ABB staff. In this way, ABB can produce metal sheets not just for its own use – while it used to purchase 80% – but it can also become a supplier for other firms.

Different production lines are now connected by a rolling stock system, which transports materials and components and is guided by MES. The system knows which components are necessary for each panel being assembled, and gives instructions on the location of components and their destination within the plant. For the time being, this system is not 100% automated: it still requires that an employee follows it and monitors its functioning. However, the implementation of this system strongly reduced manual handling of parts and components, which was entrusted to an external supplier.

Logistics also underwent relevant modifications in the latest years. The warehouse was physically moved 300 meters outside the plant. Here, components are received and stored in the corresponding shelves, from whence they are taken by the rolling stock system and directed to the production lines.

The enterprise resource planning system is SAP ERP, which manages all company transactions such as purchases, shipments, etc. SAP ERP and MES must communicate with each other, and therefore the two systems have been integrated. It is important to stress that we are not confronted by the centralised management of production, but rather of an integrated system for managing the organisation of labour and production.

Other elements of Industry 4.0

Safety was also affected by the introduction of new technologies. In particular, ABB developed a mobile app for smartphones called Safety-APP, which allows reporting of potentially dangerous situations. After access via company email, any worker can photograph and report dangerous situations. The description of the event is then forwarded to dedicated staffs, who evaluate the risk and set up the appropriate response.

Two additional characteristic elements of Industry 4.0 which can be found in ABB plant in Bergamo are virtualisation and the use of sensors. The latter are incorporated in robots, which perform two kinds of functions: final check (two robots) and testing. In its turn, virtualisation is implemented in the R&D department, where specific 3D software allows simulation and test components to be produced. This software takes advantage of all data collected during all stages of production processes, and hence simulates the assembly of MV panels, their dimensions, and their functioning.

In the Smart-Lab, it is possible to simulate the whole energy production chain, from energy production to utilisation. Simulations are an integral part of the smart-city project, and specifically, aim at monitoring energy loads and precisely locating potential break-downs in power lines and stations. This latter function is being tested by ACEA, a utility based in Lazio.

Maintenance follows scheduled maintenance agreements, while non-scheduled maintenance can be required by calling a dedicated line. Moreover, a system called My remote Care provides components with a device that is programmed to compute the residual life of the component itself. The system then remotely alerts the customer when maintenance is due – an example of this application is that of energy stations in deserts: panels incorporate a computer that remotely communicates with ABB service facilities.

These systems increased the possibilities for control over workers since all operations are traceable. Every workstation equipped with a PC with MES records everything, from breaks to operation times. The latter is established by the company and communicated to Trade Unions, but they are not subject to bargaining.

Skills and impact on employment levels

Skills acquired depend on the company's decisions. For example, for the operation of the Prima Power machine, ABB decided to train four workers, of which two were newly hired temporary workers with the possibility of stabilisation. In other cases, as for the automated forklift taking MV panels, technology took over human labour: currently, only 5% of panels are handled manually. Moreover, the forklift knows in advance what it has to do, being part of an overall planning programme. On the contrary, human workers before the introduction of this centralised systems had to ask what to do before each operation.

The impact on employment is hard to estimate. In fact, along with the introduction of these innovations, ABB industrial output expanded and changed its structure, and therefore employment levels before and after cannot be compared. The plant still employs 320 blue-collar workers, as it did ten years ago.

2.17 ALSTOM – SESTO SAN GIOVANNI (MI)

Alstom is a multinational company producing trains and railway infrastructures (rolling stock, signalling systems, etc.).

The plant located in Sesto San Giovanni (Milan) is devoted to the production of traction systems, i.e. the system for the management of train electronics and train movement; it is made by an electronic and a mechanical part. Hence, the plant produces a specific component and supplies final assembly (which, in Italy, takes place in the plant located in Savigliano. Other European plants are located in Poland, Spain, and France). It performs an intermediate production stage and hence is at the service for all other plants of the Group, which are its "customers". If one of the final plants delivers an order, the plant in Sesto acquires it and starts production to comply with it. The same production realised in Sesto is also realised in France.

The final product, therefore, is utilised by different production units: the design authority is in charge of the overall management and coordinates all interested plants through a platform. Traction systems can, therefore, be realised either by the Italian or by the French plant, according to current workloads and necessities. Alstom favours one-product manufacturing units, which makes inter-plant issues communication to arise.

Connection of the plants

For this reason, the connection of all plants of the Group is one of Alstom main objectives, as stated by the company itself: "Boosting operational performance also involves standardising products and services, ensuring a flexible industrial organisation, improving project management, and pooling working methods and tools. Alstom has introduced initiatives in each of these areas, including the deployment of a single ERP system for all sites to promote real-time collaborative work, along with digital development tools and improved resource planning."

Suppliers network

As soon as an order is acquired, orders are delivered to suppliers. Alstom supply chain supplies mechanical, electromechanical and electrical couplings. As a general rule, labour intensive activities are performed in low-cost countries in Eastern Europe, North Africa, India, etc. Electromechanical equipment, such as switches, are supplied by ABB and similar companies; carpentry is realised by Eastern European and Indian (or from other low-cost countries) suppliers; transformers are supplied by external companies, which are Italian only when a high technological degree is required; wiring harnesses are provided by Indian or North African companies. The production of electrical boards was also externalised.

The supply chain is quite consolidated, as required by the need of product standardisation. Of course, this extremely wide supply chain must be closely coordinated.

The already cited report published by Alstom stresses that, "[s]ince Alstom purchases 60% of the products needed for its activities, it also empowers suppliers as part of its drive to achieve operational excellence by involving them in the development of its products and establishing Alstom Alliance partnerships (see inset) with key suppliers to reduce the cost of designing key train components. [...] The Alstom Alliance programme unveiled in 2015 aims to create special partnerships between the Group and its key suppliers to help them grow, share innovations and develop key components together. The programme now includes 35 suppliers and embodies Alstom's commitment to better serve its customers and their passengers by offering mobility solutions that focus on quality, cost-effectiveness and reliability".

Raw materials and components reaching Sesto are stored in a warehouse area, where they are recorded, classified and stored. Quality is certified by suppliers themselves, while in former times this task was performed by Alstom employees that are now in charge of other duties.

Supplied components are recorded using optical bar code readers; the very same readers are used both by the assembly and by the testing departments. This system allows certifying the various production stages.

The warehouse supplies the workers with the required components; the informative system is provided by IBM.

The production process

Production orders are managed by the planning office, which checks requirements and creates the conditions for production departments to be supplied with all necessary parts and components.

Production takes place along an assembly line, according to just-in-time logic. Only one assembly line is automated; the others are managed manually.

Assembly consists of four steps, each made by at least two stages.

Formerly, production was organised in isles, but in order to keep costs low Alstom decided to go back to a flow system. Assembly lines do not always work as planned, which is often due to lack of materials.

The parts and components necessary to fulfill orders reach the line from the warehouse; transport takes place on partially automated trolleys traveling on magnetic tapes. Trolleys are programmed to reach the different workstations according to a planned sequence. It is possible to follow the whole path from any PC; the department is equipped with terminals available for workers to check which materials they are waiting for.

Workers use a tablet to record operations and components. Tablets were introduced to serve as instruction manuals.

Tracking system and data collection

From the point of view of the tracking system, all data entered by workers are stored in the tablet's memory and are available to the people in charge for the quality and for the end of line testing. Alstom is equipped with virtualisation tools, i.e. train operation simulators.

Another field of application of Industry 4.0 is the integration of information along the value chain, starting from big data on the functioning of trains. Cloud is available to designers; the engineering team of the plant located in Sesto also works with shareable Group platforms.

Work organization

As anticipated before, the real change was the modification of the production method, from a flow system to production in isles, back to a just-in-time flow system. The main innovations, therefore, concerned production organisation. On the basis of these innovations, technologies were adopted to facilitate the flow of production. In this respect, tablets are both a monitoring device and a tool for smoothing the production flow, since it provides workers with all necessary instructions.

However, the fact of having to follow instructions provided by tablets reduced workers' autonomy: "in former times I did set up worksheets, I followed the whole production process, now information are entered by a third person."

Hence, work was also fragmented and divided into several steps, while in former times workers followed the production process as a whole. Even if the production chain is not rigid, the realisation of each stage is subject to times which workers must keep. These working times were defined by the times and methods office, which deals with industrialisation.

Since each worker is in charge of one specific operation, Alstom introduced workers rotation in to make them learn all stages.

Some years ago Alstom kept WC updated, informed and involved, while now it is very hard for workers' representatives to get prior information.

Planning is centralised in Paris premises and is adjusted weekly according to deadlines (prototype, first train, third train, intermediate batch, etc.). Planning provides for the delivery of a specific number of trains by specific deadlines.

In their turn, plants like the one in Savigliano, assembling the final product, make their own planning to comply with framework contracts; as a consequence, each supplying plant needs to make its own planning, subject to that of the final product. In Italy, therefore, the head of the chain is Savigliano: planning starts from there and then drops down to the other plants (Lecco: railway components and energy transmission systems for subways and tramways; Sesto: train, subways and tramways traction systems; Bologna: signalling installations; Florence: train signalling systems; Rome: urban and mainline infrastructures; Naples: maintenance).

Production is organised just-in-time, on the basis of customers' orders; starting from orders, planning moves backwards to ensure a smooth flow from production to materials reception.

2.18 ST MICROELECTRONICS (STM) – AGRATE (MI)

STM realises products for a wide range of uses: semiconductors, integrated solutions, optoelectronics, circuit protections, electro-mechanics components, sensors, electrical power devices. Possible applications include automation, industrial machinery and equipment, transport and automotive, connectivity, power generation and distribution, Internet of Things, lighting (LED), medical sector, engines control, personal and multimedia.

In its premises in Agrate (Milan), STM produces semiconductors.

Design

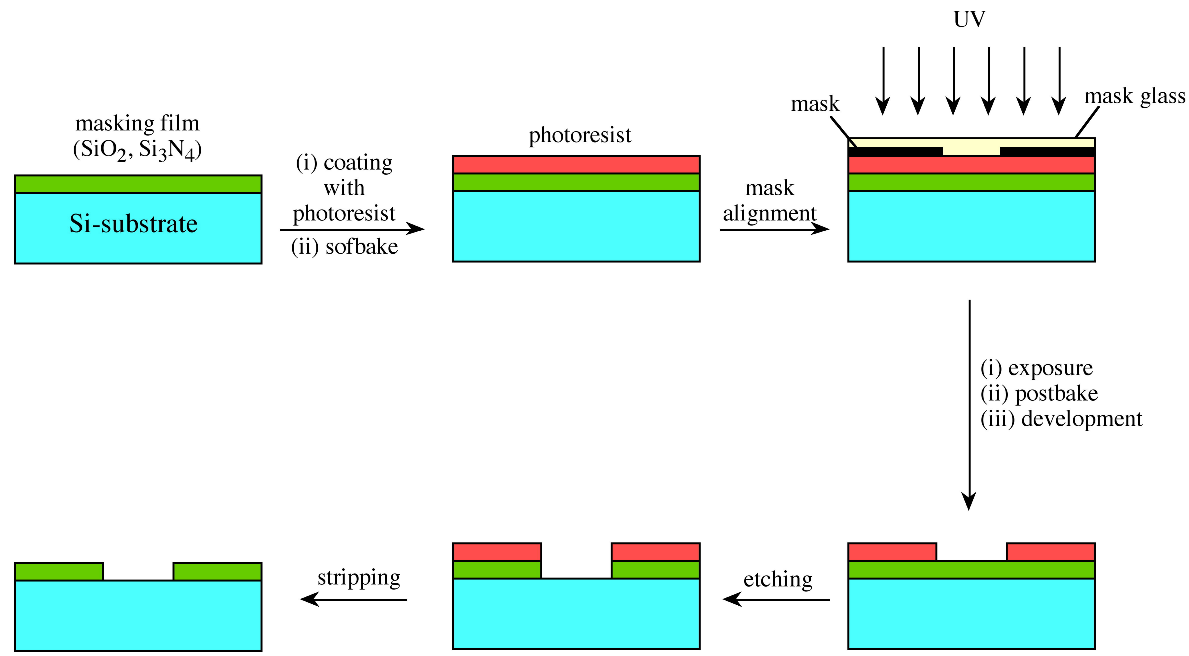
Semiconductor design automation aims at foreseeing, before assembling the chip, the behaviour of silicon components of the finished chip itself, using physical and numerical principles. Simulations may concern the electronic behaviour of the semiconductor, but also its very production process, with the possibility of simulating the physical interaction with silicon of three-dimensional structures.

In particular, the digital design takes advantage of CAD, which is much more advanced than analogic design. Digitalisation allows using high-level design languages (the designer defines the circuit's behaviour in terms of input and desired output, and then CAD realises the circuit and its actual silicon lay-out).

Change, within design sector, have been relevant: an interviewee stated that "until yesterday it was about 'art' and craftwork more than technology, it was good designers who did the circuit. Now the process is defined by automation to a much greater extent. Some time ago, workers were more specialised; now these workers turned into some kind of standardised workers."

Actually, automation aims at making design output uniform. Overall, professionalism lowered: "there is a lot of automation in design activity, algorithms which makes things much easier." In

Figure 2.2: Lithographic Step



other words, "the task of the company, also in design activity, is having workers pressing a button to start software tools which do all the job with no mistakes."

The whole production cycle can be summarised as follows. Technical specifications are provided by the customer – or internally defined in the case of a launch product; these are used by developers to draft a first design, which is then refined by the lay-out department through the definition of rules. The design is then passed into prototype production, the stages of which are organised and followed by a process engineer, who reports back to design and lay-out departments. The design is further refined and stabilised on the basis of feedback received. The aim of the company is, of course, that of making this input-output flow as fast as possible.

In order to minimise problems and slowdowns, rules have to be defined as rigorously as possible; this is the task of the so-called 'process developing kit', who organises rules into software tools to direct processes.

Making design process as fast as possible means reducing production costs. In the case of STM, this means introducing CAD in all design stages, advised by companies specialised in the provision of CAD. This includes implementing 'productivity increase projects' which count the number of times a function is performed, software crashes, etc., and documents all the steps of the design process.

Workers are subject to close control and are put under pressure in order to make design faster and hence speed up the time-to-market.

It seems, therefore, that Industry 4.0 is not reducing employment in the design sector, but rather changing its nature: less specialised, more automatised, totally traceable, subject to the definition of standard procedures aiming at squeezing design stages as much as possible. The introduction of CAD is crucial in this respect: the knowledge of designers and developers is turned into tools and algorithms.

Manufacturing

Talking about the very manufacturing of semiconductors, an interviewee reported that in the past production was organised in such a way that each worker directly followed all the different stages of his own job – for example, the whole lithography. He knew each different stage, results, consequences, and was able to check compliance with lay-out. The participation of workers in the production process, which is a very complex one, was much more intensive than it is now.

Figure 2.2 describes a lithographic step, which consists of several stages. Each stage (from six to nine) is in its turn made by tens of further sub-stages.

The different stages are carried out by machines programmed to accomplish a specific processing. Each machine follows a specific recipe according to the product to be delivered. These recipes are programmed and stored in a server. Machines are provided with FTP communication protocols which can manage the download of the appropriate recipe. The only task left to workers is to specify the task to be accomplished; detailed instructions are then provided by the corresponding recipe.

The FTP communication protocols used by STM are specific for semiconductors industry and are provided to lithographic machines by the manufacturers who sell them to STM. They play the role which was formerly played by workers, who picked the recipe appropriate for the item to be produced, uploaded it and started the machine.

The path followed by silicon is defined by R&D department; the overall production flow is a sequence of scripts. The infrastructure on which the flow is based is called 'Workstream', and works like MES.

By interacting with Workstream and following the scripts, workers accomplish a double task: they move each specific batch from one machine to the other and keep track of its manufacturing process. "In this way, it is always possible to know where each specific batch actually is; a software automatically processes cuts of silicon, follows them in real time and interact with the different machines." Workstream scripts provide workers with basic information only, limited to the path that each batch has to follow within the production flow.

To summarise, each batch has to follow a specific path, designed by R&D, through different machines. FTP protocols installed in each machine allow to access the server; Workstream interacts with both the server and the machine, picking from the former the recipe to be delivered to the latter. Recipes are programmed by the IT engineers, on referral from R&D department.

Workers' deskilling is apparent: they do not prepare and follows recipes themselves – which allowed them to know the whole process – but they just have to load and unload batches.

The whole process is almost completely automatised: workers unload the batches, identify them with a bar code reader, the information is passed to Workstream which identifies the appropriate recipe and upload it to the corresponding machine via FTP protocols.

2.19 MAGNETI MARELLI – CORBETTA (MI)

Magneti Marelli, which is part of FCA group, supplies big carmakers OEM – such as Audi and Porsche – with hi-tech systems and components. The plant in Corbetta produces displays for dashboards, inverters and engine control unit for several carmakers, among which Porsche.

Porsche has adopted a productive model which allows customers to order their vehicles and fully customise them. Orders are managed by a centralised informatics system that synchronises all actors involved in the chain. As such, the Magneti Marelli plant located in Corbetta (Milan), periodically receives production plans through Electronic Data Interchange (EDI).

Five days before assembly takes place in Germany, Magneti Marelli receives, via Value Added Network (VAN) the order to start producing a specific sequence of board tools which will be then assembled in the Porsche plant. A dedicated platform makes design and standards are available online to all suppliers. In its turn, EDI allows documents exchange between informatics systems.

Partners can electronically share orders, transport documents, invoices, inventories, price lists, etc. through a common language with defined standards integrated with ERP.

Moreover, Magneti Marelli employs Tesar tools such as Motis1 and Motis2. The former, Motis1, is an integrated planning and controlling system of production: it allows integration with warehouse and real-time collection of data via industrial devices directly connected to machinery. Motis1 is a software for production planning and scheduling, optimising a) the workload of each machine and human being, and b) the performance and productivity of the entire company, taking into account priority orders, deadlines, inputs, productive urgencies, the potential of departments/machinery/processes, through-put times, and unproductive times.

Motis2 is a Manufacturing Execution System (MES) software for production management, data collection and monitoring. It allows to control and manage the production process taking into account both the statements of progressing activity and the automated monitoring of production parameters of each machinery and equipment. This interactive management generates a complete and powerful system of real-time supervision, statistics, reports and indicators. The software is embedded in each machine. For example, pick and place machines are controlled by a software that identifies the right components to be placed on circuit boards.

Interview with RSU (WC)

from the point of view of orders, which start the production process, the peculiarities of Porsche are stressed: “Porsche is a particular customer because it does not order on the medium-long run, but on a daily basis, and deliveries must take place in four days.”

Dashboards

The starting point for the production of dashboard is a bare circuit board, provided by suppliers located both in Italy and in Northern Africa. These boards are then equipped with a series of automated machines, working by production scripts launched by a dedicated worker.

For instance, the first machine of the sequence loads the boards and label them. Labelling is fully automated: workers only have to read the batch code and launch the corresponding script.

The code is specific to each batch; the worker responsible for the progress of production receives the customer's order to its PC (for instance, 400 Audi boards); then, the head of UTE (Unità Tecnologica Elementare, Elementary Technological Unit) receives the list of codes to be produced by each line. Production planning, which follows orders acquisition, is done on a weekly basis. Porsche is the only customer whose orders can be met immediately, due to a special clause.

The head of UTE has the power to set priorities.

The following stage is putting the welding paste on the board: also in this case, the job is done by an automated machine working on the basis of a script.

Instructions to line workers are printed on paper and available at each workstation: they provide for the codes of the batch and of the single production stages to be performed. Workers, therefore, know which scripts to launch, both for the production cycle as a whole and for every single machine: "normally, we upload scripts for all machines, but sometimes it is done step by step. [...] if the complete script has already been uploaded to all machines, we only have to press the start button, otherwise we upload it when necessary. [...] However, upload is done in one minute, there is no much difference."

Hence, normally the first task to be done every day is uploading scripts to all machines; afterwards, these scripts are launched at each successive step.

A conveyor system links the various machines.

When the welding paste is in place, another machine assembles the various components, which are of two kinds: chip shooters or pick and place, according to the production line; all the new lines are equipped with pick and place (Fuji and Hitachi).

Also, the task of taking and placing components is performed by automated machines according to the script corresponding to each specific batch. The main components are transistors, resistors, condensers, small motors, connectors, microprocessors, of different sizes and shapes; these components are supplied by external contractors in packages, except for microprocessors, small motors and connectors which are mounted on panels.

Once boards are equipped with all necessary components, a conveyor belt lead them to a furnace where they are subject to a melting process and then cooled with fans.

The last stage of the cycle is cutting the boards with a dedicated machine.

A warehouse worker transports boards and components to the line and place them in such a manner that operator move as little as possible; transports take place by driving a trolley on tracks. The warehouse is partially automated, but trolleys are loaded by workers. The software for warehouse management is SAP, which was introduced 3/4 years ago.

A system of data collection also exists: each machine generates data that are centrally collected and stored. This system, introduced a couple of years ago, makes the monitoring of the whole production line possible.

Each line is equipped with a monitor; technologists can see it from their workstation and use it to get data about the production process.

Moreover, each machine tracks the start and end of each production stage and carries out its operations in a specific time according to the specific product to be obtained. The informative system, makes monitoring the whole cycle and checking compliance with cycle-times possible.

There is also a tracking system in paper form: workers fill in specific forms reporting failures, machine stoppages, quality issues, etc.

every morning, the technologist collects reports and compares them to data collected automatically, and matches them.

When the board is completed, it goes to testing, performed by programmed machines which, at the end of the process, deliver a coupon providing for testing results.

At this point, the board is placed in a plastic case. A flat is introduced manually, but a machine equipped with cameras immediately checks whether it is done correctly. The following stage is that of attaching polycarbonate (speedometer, odometer, oil and gas levels, etc.): the case then is transported by a conveyor belt under a press and, after that, tickers are put in place by an automated machine.

Finally, everything is closed with plexiglas and goes to final assembly.

Control units and inverters

In the case of control units (for motor, windows, etc.) the production cycle is less complex. Boards are loaded by a robot. Parts and components are transported from the warehouse by robots pulling a trolley following dedicated magnetic strips; they are programmed by warehouse workers to stop at each specific workstation.

Parts and components are dropped off at kanban (introduced by WCM); workers take them to perform their tasks.

Inverters are another production of the Corbetta plant, particularly demanded by Chrysler, BMW, Mercedes. The production process is the same as for electrical boards.

The silk-screen printing department

The silk-screen printing departments supply production lines. Raw polycarbonate is dyed in different colours for rev counters, odometers, oil indicators, etc. This production stage is performed by NC machines (Sakurai e Atma) according to a production code. Production orders are electronically to the department's PC through SAP by the Production Office.

Technological degree

Machines are characterised by a very high technological degree. COMAU supplied a robot in charge of positioning control units. Another robot in the plastics department loads masks.

As to machines automation, it is described as "very high".

The company tracking system (VALOR) "recognises and signals any mistake in assembly." Each package of components shows a label; when the package is picked up, the code is read with an optical reader which provided information to the feeder. If the code is wrong, the system detects the mistake. Each assembly line is provided with a manual called "Foolproof", which provides for all codes of the products to be processed.

This tracking and recognition system also takes action when a board does not pass inspection.

Workers gave a positive assessment of this aspect, even if according to them the system implies some rigidities that do not always make working easier.

Production lines

U-shaped production lines are not equipped with a conveyor belt and employ four workers at most. They produce components for Porsche and Macan, Minicargo, Ducato, Iveco, Maserati, FCA, Audi, spare parts (Ferrari, Maserati, Bravo and Delta). Line 28 produces for PSA, while Line 32 for Maserati.

On the contrary, the line producing for Audi B9 works with pallets and is semi-automated; all lines producing control units are fully automated.

Machine Team Leader

Machine leaders are an intermediate position between the head of a department and the team leader. Three machine leaders were introduced to work at electronic lines as first responders, while a super team leader is in charge of assembly lines. "They should solve problems, but actually they have to ask us what to do. [...] hence, interventions take longer."

Supplies to Audi and Volkswagen

As regards Audi, the only production left are those for Audi B9, since the company missed many procurements. Audi asked for a specific quality level in labour organisation: shoes equipped with chips, badge stamping, turnstiles, etc. Moreover, Audi's technical experts visited the premises in Corbetta for a whole day to monitor labour organisation.

The production of control units for VW is also going to be subject to strict controls by the customer: VW technicians also visited the lines to see how they are organised, and much likely they will intensify their inspections in the future.

2.20 GENERAL ELECTRIC – TALAMONA (SO)

The GE plant located in Talamona (SO) produces palettes, diaphragms, nozzles: all the components for the Oil & Gas sector, in particular for turbines (gas or steam) and compressors; these components are delivered to the plant located in Florence, where they are assembled to stators and rotors. Hence, production orders start from Florence.

Orders mode for components produced in Talamona changed through time: "now we get orders in real time, while before we made a more intensive use of warehouses. Now either production is still, or we have to work hard and fast to comply with delivery times."

First of all, planning and production departments order all necessary parts and components. The main supply is represented by micro fusions, i.e. valuable components mainly coming from Germany and France. Micro fusions are used to produce rods for the gas sector.

Oracle is the software in use for the management of orders and warehouses. The production plan is available to departments on paper and provides for all production steps.

Gas-powered blades

The production of gas-powered blades starts from micro fusions; when the batch of blades is received, it is associated with a set of serial numbers, one for each blade. The serial code is entered into a PC by the team leader, and then red by the dedicated worker. This system allows checking which production stages have already been performed. The operations tracking system is done with an optical reader which allows recording the start and end of each single production stage.

The basis of the blade is realised by two NC grinding machines, already set up with process data. The dedicated worker just launches a script.

Scripts are programmed by the Computer Numerical Control (CNC) office, and then uploaded to the company server from where workers can launch them thanks to the fact that machines and the server are networked.

Production cycle instructions delivered by the competent offices provide for blade codes. Each machine is equipped with a book reporting all codes and the associated processing operations; each operation is associated with an abbreviation to which a specific script corresponds. The first launch of the scripts is done by the line head in cooperation with the most trained workers; at the beginning of each processing operation, the cycle is tested and finalised, and then saved to the machine.

When the operation is completed, the dedicated worker closes it by reading the cycle bar code with an optical reader, and then the production process passes on to the following machine. The whole cycle is a lean process because it consists of successive operations leading to completion of the batch.

Formerly, each machine produced a whole blades batch which was then stored in the warehouse; now, instead, the company aims at reducing batches dwell time by eliminating storage. Logistics was organised accordingly.

The following machine realises the basis sidewalls. It is started by a dedicated worker who reads the barcode and launches the script. Once the operation is completed, she uploads the code to the system with a networked optical reader.

Machines cycle times are designed to ensure meeting daily production objectives: 54 units per day and shift for smaller blades, 34 for bigger ones.

During the third stage, the vertical leaf dimension is shaped. The same worker is in charge of both this and the previous stage since the machine is an automated EDM which only needs to be loaded and unloaded.

The following stage consists of matching two blades to realise the wheel. Afterwards, according to the kind of blades, some of them are sent abroad for surface coating, which is done by contractors located in UK and Hungary, and then sent back to Talamona.

Diaphragms

Diaphragms, which are part of the stator, are produced by a new line; the production process is longer than the one described above. The company is starting to equip warehouse with robots which brings components to the line traveling on dedicated tracks. The robot is called by the line head or by the worker operating the machine.

Machines for diaphragms production are the first were the first to adopt the “brilliant factory” control system, designed by GE and adopted by the plants located in Talamona and Florence. This system allows to remotely monitor the whole machine from PC or smartphone.

In the Florence facility, a labour agreement was signed ensuring that the system is used by the company only for machine monitoring, in compliance with the law on surveillance of workers, but it is absolutely clear that GE also controls workers performance.

The “brilliant factory” system implies the network connection of all machines, so that those provided with access credentials can connect to GE server and monitor them even with a smartphone: “they can see everything the machine does, the script in use, the speed, if it was stopped, for how long, etc. [. . .] now we have to enter a reason for each machine stoppage.”

These machines are equipped with an on-board computer; a computer located at the beginning of the line shows the status of each machine.

Manufacturing scripts are launched by workers.

The department includes five machines: four automated lathe-mills and a scraper. Diaphragms are also produced to supply Florence facility.

Nozzles

The nozzles department is fully automated, it employs only two workers in charge of tools and possible machine stoppages. “Robots are in charge of all other operations. [. . .] when production is completed, a robot takes the piece and sends it to testing.”

Also in this case, micro fusions are the starting point: they are delivered to an automated line where all processing stages are performed by NC machines, automatically managed by the line itself. In this case, the dedicated worker is only in charge of machines equipping, and masks preparation.

This line is also networked with the “brilliant factory” system.

Additive manufacturing (3D)

This department is very recent and consists of three machines, two of which are already used to produce prototypes for a specific component of the turbine. The project has been managed by the Florence plant.

Additive manufacturing works with chrome and other heavy metals dust for which a specific HS management is provided, in a protected environment and following specific security procedures.

From the point of view of workers, the greatest transitions concern the fact that dedicated workers must be able to operate all machines, and a greater degree of flexibility – which the company calls ‘versatility’ – is required. Workers appreciate versatility because they can learn new things, but critical issues are of course present: “some people, and especially senior people, have difficulties.” Moreover, the company does not seem willing to remunerate such versatility.

2.21 KOSME – ROVERBELLA (MN)

Kosme designs and produces a full packaging and beverage line. It is part of Krones Group, headquartered in Neutraubling, Germany.

Interview with management

Kosme intends to face the challenge of Industry 4.0 in two ways: both as users and as suppliers. Industry 4.0, first of all, implies that machines turn into tools for providing services to customers, as it happens with networked cars, providing information on the status of the car, signalling the need for maintenance or refuelling, etc. The same idea could apply to automated machines able to provide services to customers and hence secure their loyalty (customer loyalty programmes do not concern only the mere supply of the good, but also the whole range of services which the company can provide) and get them used to interact with the machine and with the company which supplied it. Recently, the company presented "Kosme for industry 4.0" at the Drinktec Exhibition in Munich (beverage and liquid food automated machines): it is a package of new generation machines equipped with new and powerful software and connectivity services. The task is that of increasing reliability and reduces stoppage times. According to Kosme, customers mainly require machine user-friendliness and continuous improvement: when a customer requires modifications, these are provided electronically, together with showing a Kosme employee equipping the machine. Moreover, the machine records breakdowns and transmit the corresponding information to the headquarter, which gives instructions for maintenance. The machine itself can provide a list of replacement parts which the customer can order, directly from the machine. If an error persists, the machine records it; information is elaborated by the big data department; the list of replacement parts and the machine diagram are projected by the machine itself on a screen, with the indication of necessary maintenance and of the corresponding spare parts which the customer can confirm. This system works thanks to an internal database which passes on information to the machine. The latter can, therefore, prepare a document and convert it into a QR code, which the customer can read with a smartphone send as an order upon confirmation. The QR code is projected by the machine on a dedicated panel, so that a dedicated worker can read it and, with the same smartphone, email the corresponding order to Kosme. Kosme implemented a direct connection between machines and the company, which does not need any intermediation. This is made possible by wireless connection and thanks to internal documentation allowing machines to elaborate relevant information.

Machines are also equipped with a system which, in the event of an alert, opens the dynamic electrical pattern (which printed on paper would be extremely large), points out the exact point where the problem is, and open the corresponding pictures. At this point, a communication interface opens up, connecting to Kosme technical support. Thanks to a system of panels equipped with cameras, it is possible to communicate with Kosme operator, who can take pictures and videos transmitted live to Kosme technicians, who can see the problem and give the required information. Kosme disseminates scientific and technological information about machines through a specific App for Android: customers enter the access credentials and can see all the technological update of her machines. In other words, machines produced by Kosme are nodes of an internet network. For instance, a glue warming machine needs to enter standby mode, which depends on ambient temperature. The internet node connects to the website meteo.it and then computes the exact standby times.

The handling of orders, materials reception, planning and scheduling are managed with SAP: more specifically, it is a CAD connected to SAP – in charge of material management in the turnery – and Iungo – a system for automatic purchases from suppliers, assembly scheduling, delivering and testing system.

As regards internal processes, Kosme abandoned the previous ERP and is implementing a new SAP which should be the basis for a breakthrough towards modularisation, standardisation, pre-assembly, and lean production, in order to lower production costs. The database system formerly in use was Oracle, while now SAP has its own database system. SAP is now in the cloud: Kosme is leading the way for the whole Krones Group. Currently a common Group system does exists, and SAP was owned by the parent company.

In former times, Kosme could not realise some operations because it could not take advantage of SAP. For this reason, an 18 months programme is going to be launched to modernise internal production, which does not consist only of assembly, but also of design, configuration, materials management activities: "in order to do so a cultural leap is necessary, with specific formative moments. The management must also make a quality leap with specific training because processes are fast and they also have difficulties in keeping up with this."

Interview with Worker Council

Many parts and components are supplied by external companies. Since Kosme is affiliated with Krones, it is also a customer of Krones itself for some supplies – fill valves, adhesive groups, etc. – for which Krones signed purchase contracts with Krones. Other relevant suppliers are Rossi and Sev for engines; Mormoinox and Consol for machines protection. As regards electronic components, since the sector is very wide, suppliers range from Siemens to Keice (for cameras).

The supply chain is extremely wide and constantly evolving; for instance, to new doors suppliers have been found which charge lower prices.

SAP

SAP is a technology which Kosme shares with Krones. Kosme also takes advantage of Krones' sales network. SAP allows to share commercial offers and technical documents; hence, machines detailed description and commercial offers are filled in SAP which, at this stage, is shared by the two companies. Once the order is acquired, it is taken over by the technical office which employs 3D design tools (CAD and PDM management tools, i.e. a database collecting all pieces realised in the past).

The design takes place in two stages: the first is the design of the standard, which has to be manufactured in advance. The second is the list of all necessary components: some of them are stored in the warehouse, while others have to be purchased from external suppliers. The list of parts and components is registered with an optical reader, and data automatically go to SAP. On the basis of production orders, trolleys are loaded with the required parts to be delivered to assembly workers. SAP is also used for warehouse management; information concerns the kind and the number of parts and components and their destination (i.e., the machine to be assembled): "it is again SAP that builds production orders, with the indication of components to be used and where to put them. [...] SAP knows where to put each and every part. [...] Used parts are recorded both in the warehouse and at the assembly department so that SAP can trace back when and where they were used."

The turnery

In the turnery, working times are periodically recorded, for the company to compute production costs of each piece and check whether is economically efficient to produce it internally rather than purchasing it from an external supplier. In other words, the department has to face the competition of external suppliers.

The dedicated worker provides the machine with production instructions for the various stages and records the start and end of every single stage. Thanks to these measurements, as stated above, the company can compare costs between internal production and external supplies.

The responsible of the turnery receives to her office PC the design with the indication of all pieces to be produced; then, the cycle and the corresponding stages is drawn up in the turnery department. Here, the production scripts for some machines, for instance, lathe-mills, are defined by the workers themselves. In the case of other machines – such as milling machines, plastic working machines, and laser machines – scripts are programmed by dedicated technicians who also upload them to machines; workers only have to equip and load the machine and launche the corresponding script. Some scripts are directly programmed on the on board computer, for others there are dedicated workstations equipped with an ISO PC where the 3D design is downloaded and the different production stages programmed to get the final ISO script to be launched from each machine.

The company takes advantage of a tracking system. Designs are associated to three different barcodes: one identifying the machine to be used, one identifying the production order, and one to record the start and end of each stage. At each operation, the three codes are matched and the corresponding data stored. These data are extremely useful for the company because they allow to single out operation times and hence compute production costs.

Workers in the turnery have a critical opinion of this tracking system: "in former times, we just handed in the final product. [...] Now they see everything, the cost per minute, the time taken. They see that some workers take more time than others." Last year the responsible used to show every day a worksheet where working times of various machines were indicated in different colours, "to single out how they worked, [...] and if a machine had been working for five rather than eight hours, nobody asked what happened."

Still talking about traceability, designers must fill in a form on the platform indicating the various activities performed and the corresponding working hours.

Assembly factory

In the assembly departments operations take place in isles; workers are put into different teams and record their working times and the performed operations through barcodes showing the kind of machine they are operating. Concerning turnery, however, times are longer since the kind of operations performed are of a very different character. Tools used for assembly are drills, angle grinders, wrenches, screwdrivers, pliers, scissors, etc.

In the first stage operations are relatively more handcrafted, especially in the assembly of the machine which works like putting together the pieces of a puzzle; then, they become more specialised. Since we are talking about hi-tech machines, the final assembly stage also is the first testing stage. Kosme realises a wide range of products and hence testing is diversified, but all testing operations are very rigorous and take advantage of photocells, cameras, PLC recordings, flowmeters, etc.

Remote assistance

One of the main innovations introduced is remote assistance, which can be provided for by resident technicians operating machines and concerns assembly and maintenance; remote connections even allow to directly connect to the customer's machine. As regards technicians, i.e. the service department, they can take advantage of pictures and videos sent by the customer. This also happens when customers ask for improvements.

The final assembly of each machine takes place at the customer's premises; this activity is supported by various Krones service teams assigned to support local teams.

If remote assistance is not possible – because of the machine characteristics – assistance is given through smartphones, touchscreens, etc., connecting to the head office which can provide assistance after checking pictures and videos.

2.22 COMER – REGGIOLO (RE)

Products and customers

Comer Industries produces power transmission mechatronics systems for agricultural and industrial machines manufacturers, of which Comer is a partner in more than 60 countries. The facility located in Reggiolo produces gearboxes for agricultural and earth-moving machinery; including boxes, gears (formerly produced in the plant located in Moglia) and fixtures. The main customers are CNH, Class, Caterpillar, John Dear, Kverneland, Bobcat, Agco, Siloking, Alamo Group, Volvo, Mitsubishi Heavy Industries.

Supply chain

The supply chain is very extensive and includes a wide range of parts, components and materials.

Almost all parts are provided by external suppliers, also located in foreign countries such as China, India, Turkey. Company publicity pays great attention to the supply: the website states that "Comer Industries has decided to implement the GLOBAL SOURCING portal as a decisive step towards operational excellence and business processes of its supply chain. The portal is an excellent vehicle for communication and integration with suppliers". Beyond internationalisation, Comer supply chain has quite strong local roots.

Just-in-time and supply chains: critical issues

Parts, components and materials supply is often late, which causes many difficulties, e.g. for assembly. The crucial node is the organisation of just-in-time production: the company wants to dismiss inventory management, which necessarily widens the supply chain.

In its turn, Comer supplies components to agricultural and earth-moving machinery manufacturers, which reflects on its entire supply chain. Companies like CNH enter into three-years supply contracts, but each year they want a discount on previous year's cost: this creates cost pressures, and hence pressures on workers.

Moreover, on-time-delivery is one of the indicators entering performance benefits, and hence influencing wages.

The organisation of the production process

When an order is acquired, it is taken over by the TMA office; afterwards, the technical office designs the specific product with CAD and delivers it to the times and methods office. The project is to the corresponding departments is made by email through the company intranet. The organisation of labour in the various departments, deliveries to different operators, the allocation of orders/codes to the different machines/workstation is based on the so-called "mornings", i.e. small meetings held in the morning.

The information system

Information about production and labour organisations are written on department-specific billboards, indicating all the codes to be produced (barcodes) and the machines to be used for processing of each specific order. This information is forwarded to workstation monitors, which also perform many other tasks, such as visualising the pattern of the piece to process (work order), knowing the exact quantity to produce. In other words, they provide complete information about what is to be produced. The "planner" updates orders – i.e. sets out priorities – using a computer, located in the department control room, connected to the information system. Updates are also transmitted to workstation monitors.

At each shift, workers start their work by following a specific procedure based on SAP: enrolment, display of the codes of the products to be processed in the monitor of the machine, with priorities emphasised. Each machine operator recognises codes by means of an optical reader which opens the pattern of product to be realised while reading the code itself.

The engine room production cycle

Machines producing cast-iron boxes are loaded by workers. Components are provided by a trolley driver (mitzumashi). Machine production cycle times are provided by a barcode. "We can, therefore, say that bio-rhythms are subject to machine times. [...] No stops are made, it is like not taking any break because breaks have been absorbed by machines. [...] Our job is bound to the machine. [...] Besides running machines, we have to perform control, washing, deburring, swelling activities, [...] as well as tools check. Hence, we have a very high saturation." Time saturation is given by the fact that workers do not only run machines, but they have to run two or three machines at the same time, as well as carrying out auxiliary activities.

Comer is provided with a performance tracking system which could even go further. The start and end of each operation are recorded by each worker who, at the end of the working day, must also record the quantity and quality of pieces produced. The new system (ZK monitor) can track performance in real time. The company describes this system as a tool to monitor plants efficiency, not workers' performance directly. However, since human work is constrained by machines, it indirectly monitors working times as well. In other words, due to the existing close man-machine correlation, controlling machines implies controlling workers performance in real time. The company can also take advantage of a software for remote control of the functioning of machines. "In fact, they want to control us, [...] because we are the muda."

Machines work on the basis of embedded programs which workers only have to launch. Programs and equipment are prepared by toolmakers.

According to WCM, workers must also take care of production self-control.

SAP

People in charge of the operations are provided with a tablet for machines remote control. The information system is based on SAP, which collects all data: it records parts, components and materials entering the plant as well as final production output. SAP allows to manage and record all activities, from launching production orders to filing complete productions, as well as to record problems encountered, downtimes, etc.

New technologies, therefore, make remote control possible "via monitors which can detect whether a machine is working or not, [...] via software on tablets and smartphones allowing to monitor machines even from home."

Performance traceability is also possible via batches traceability: "[W]ith these technologies, the company can trace back to the batch and to the workers who processed it, because a specific tool takes note of the date and hour printing them on every single piece."

The assembly department, besides SAP, is provided with columns (WCM) to specify advances. Here, by implementing WCM, the company organised the supply of part and components in such a way that the worker, in principle, should be equipped with everything she needs along the line, thanks to the work of kittari and mitsumashi. In practice, there are many problems, often due to the lack of components and to the insufficient number of kittari and mitsumashi themselves.

Plant's utilisation (and labour's exploitation)

To increase capacity utilisation, the company aims at organising production in 20 shifts. A particularly insistent demand by the company is that of adopting flexible hours. An additional problem is given by the fact that talking about labour organisation is taboo for the company: "they do not want you to talk about labour organisation. [...] Labour organisation bargaining does not exist."

Surface coating

The company realised a relevant investment in surface coating. The management of the plant is based on a double-shift software, controlled by a dedicated worker. The worker programs the codes sequence, and surface coating is carried out by an automated facility with one thousand sensors continuously supplying real-time information about the process, which is remotely controlled by a dedicated worker provided with a handheld, wirelessly connected, for the management and control of the facility itself.

Performance and productivity benefits

Performance benefits depend on technical indicators and on Ebitda, and more precisely on:

- Ebitda – for 35%;
- high-quality outcome (PPM): internal (PPM Machining) and external (customer-oriented, PPM Customer) – for 25%;
- OTD (On time delivery), timely deliveries – for 10%;
- productivity index – for 30%.

Productivity accounting takes into account total plant operating time (OEE) as well, i.e. an indicator which does not depend on workers' performance.

Specific reports highlight plants operations, identifying with different colors the various stages of activity: actual operating time in green; set-up in grey; ordinary downtimes in blue; maintenance in purple; "performance losses" not else classified (due to slowdowns caused by non-complying materials, by human performance and by malfunctioning procedures) in yellow; finally, "defects and reworks" and facility failures in two different shades of red.

OEE stands between 68% and 77% of total time.

This indicator is also part of the wider detection of technical Key Performance Indicators (KPI, a WCM tool measuring the pursuit of intended results) linked to performance benefits.

The informative system and SAP record all specific reasons for the plant not being fully exploited, e.g. electrical faults, equipment failures, lack of materials, machines set-up, pending DEA controls, toolmaker awaited, etc. The same system exists in the assembly department. Possible downtimes reasons to be reported also include trade union meetings, strikes, etc.

All downtimes, hence, are reported through SAP directly by the worker dedicated to the corresponding machine. These reports are followed by the so-called Control Reports (RC).

2.23 CARPENFER – REGGIOLO (RE)

Production and main customers

Carpenfer produces components for agricultural, industrial and earth-moving machines manufacturers. The most relevant products are structures and components for the lift trucks produced, e.g., by Toyota plant in Bologna. Other customers are earth-moving machines manufacturers such as CNH, Manitou, Argo, Carraro Agritalia, Agco, Caterpillar, Toyota Material Handling.

It is one of the few Italian examples of medium-heavy carpentry; the peculiarity is that Carpenfer realises the full range of processing stages on metal sheets: laser cut, folding and pressing, machining, and welding.

Supply of raw materials

Raw materials purchased from external suppliers are metal sheets in different thicknesses and measures. The main suppliers are foundries such as Gabrielli (Cittadella) and Ilva (Taranto).

Metal sheets are cut, folded, subject to special mechanical manufacturing operations; afterwards, it goes through welding and tacking and, finally, assembly.

Currently, structures for lift trucks are the main production: on average, 80 units of various sizes are produced daily.

Organisation of production

The production program is defined on the basis of the customer requiring each specific unit. In the case of Toyota, the program is defined on a weekly basis, but it also includes daily progresses and deliveries with the *Iungo* system.

Toyota Material Handling, in fact, implemented "pull" production in order to avoid all muda in its supply chain by organising a logistic-productive flow which had a strong impact on compliance with delivery dates. In order to accomplish these tasks, Toyota strongly reduced the variation between suppliers' and customers' On Time Delivery (ODT) to avoid stocks and waste. The specific actions taken by Toyota were the implementation of: a weekly Delivery schedule; Kanban system; Junjo management (sequential orders); suppliers monitoring and awareness.

Every day, Toyota collects kanban cards which are electronically forwarded to suppliers for them to supply the required materials.

The Junjo system requires the assembly sequence to be communicated daily to suppliers and the latter to daily supply materials by the corres theponding assembly sequence. Inventories, therefore, are also managed on a daily basis.

In order to manage this particular supply management system, Toyota adopted a software, called Iungo, aimed at integrating suppliers and communicate with them via email. Toyota needed to: involve all suppliers; share information; implementing emails; track the dispatch of weekly orders/delivery plans; manage orders confirmation; increase the speed of orders transactions (modification of dates, prices, comments); manage reminders. This service was provided by Iungo Italia, a start up founded by the University of Modena and Reggio, and is based on emails as the only means of communication with suppliers aiming at building a collaborative supply chain. The system provides for a web portal integrated with management system, in which users can find a full and updated real-time picture of interactions with suppliers, to coordinate and monitor the whole supply chain.

The documents collected via Iungo during the different stages of the supply chain also allow to monitor both each supplier (confirmation rate, timeliness of deliveries, response times, reliability) and a series of indicators collecting analytical information such as the degree of flexibility (i.e., how suppliers react to modifications and new requests, which change together with the market).

In the lift trucks department, Carpenfer supplies its customers following the sequence of their assembly lines, according to the principles of just-in-sequence (JIS) production, a system which aims at exceeding the limits of just-in-time (JIT). With respect to JIT, JIS is more demanding since the former implies "right quality, time and quantity" supplies, while the latter also implies deliveries to be scheduled in exactly the same sequence as provided for by customer's production flow. As a consequence, it requires a higher degree of synchronisation between suppliers and customers in order to get a smooth production flow, with the quickest possible reaction times.

The people in charge of the various productive and administrative departments are in charge of comparing – via computer – actual production progress to production plans, and eventually introducing the necessary modifications. Administrative departments take care of orders handling, and hence can follow the state of production; updates and modifications are usually introduced every three days.

An aspect worth stressing is the high number of external, especially craft, enterprises which work for Carpenfer to realise the different manufacturing processes.

Laser cut

Metal sheets are stored in warehouses close to the laser cut machine on the basis of the indications provided by the person in charge, who get information to her office PC.

There are four laser machines, provided by Trumpf, and also some folding machines. Moreover, there are two CAD-CAM stations which manage: (i) Cad-Cam True-Tops (an all-in-one solution devoted to metal sheet design and planning; the software allows to perform several processing stages: from the 3D model to the NC program for laser, folding, and punching machines, covering all stages of the specific order); (ii) nesting cut development (an automatic procedure for optimising shaped cut: in a single step, the machine can produce all necessary components); (iii) folding programs development.

The laser cut machine takes the needed materials, according to planned activities, from a dedicated warehouse. The machine is controlled by a worker; from the PC, she gives the order to take the required batch of metal sheets and the machine processes it according to the plan. The degree of automation is very high, so much that these machines can work even by night. When processing finishes, machines print labels providing for the following stages. Workers launch these operations from de department PC using their employee code, then enter each processing stage still to be done, coupled with the code associated to the specific machine which is going to perform it (every machine has its own code: the machine code). Single manufacturing stages codes can be found in a folder reporting the specifics each machine can realise. At the end of processing the worker, again from the PC, closes it and prints the label reporting the stage just concluded and the following ones. Hence, when a worker opens a production note, she has to associate the employer, machine, and specifics codes.

Mechanical processing

Also in this department, workers receive work orders on a PC and have to associate them to its own employee code and to the corresponding machine code. Machines are loaded and unloaded by workers, who monitors the functioning and manages tools. Machines are already equipped.

All machines are connected to the company informative system. At the end of processing, realised quantities are recorded on the basis of wastes recorded by the machine.

Operations to be done by each machine are already set: workers have to associate batch in progress, machine equipment and manufacturing script. A code allows recalling a script providing for the tools to be used, the parameters to apply, the manufacturing stages to be started, etc.

The batch-equipment-script association is realised through an online connection between the machine control terminal and the terminal controlling batches entering the department. The department PC is connected to the on-board PC. The latter is used to control machine functioning.

Folding

The folding department is provided with Numerical Control (NC) machines which operate on the basis of a given manufacturing script launched by the dedicated worker. Machines automatically count realised pieces. The pattern is available both on paper and in the on-board PC, which receives and reproduces it, showing all production stages to be realised.

Welding

This department is equipped with both manual and automated folding machines. All workstations for tacking are manual. When a single piece goes to automated workstations, workers load/unload it; if the corresponding script is already available, the worker launches it; otherwise, it is programmed by the responsible.

Processing times

Working orders also provide processing time, previously defined by the times and methods office.

The orders constraint

Carpenfer works on order, and its customers apply lean production; this is a constraint making discussions about labour organisation very difficult. Handling orders is quite hard, and the urgent character of some of them imply the need to continuously switch from one order to another, with obvious effects on labour organisation and working times. Hence, it is often necessary to resort to overtimes and temporary workers.

In its turn, to face its customers' orders, Carpenfer sometimes needs to externalise some production stages and to put pressure on its own suppliers. Orders are electronically transmitted to suppliers; a system tracking externalised production stages exists, which is part of a wider production cycle control system.

Logistics computerisation and informative systems

Workers in warehouses use optical readers which record any part or component passing through different department warehouses or stored – between one production stage and the following one.

The welding warehouse seems to have a higher degree of automation: workers are equipped with a handheld which indicates the exact location of components to be stored and records any operation.

In the various departments, almost all workstations are provided with a monitor where workers can read operating instructions stage by stage. In the welding department, monitors also show the pattern of the component to be realised with the different processing stages: the dedicated worker presses a button, goes to the next step, and the pattern with the new stages appears.

In the surface coating department, monitors specify the way in which to load components.

2.24 INTERPUMP – CALERNO

Interpump Group is the largest manufacturer of professional high-pressure piston pumps in the world and one of the leading groups operating on an international basis in the hydraulic sector.

The main applications are in the sectors of construction, automotive, oil & gas, food, cleaning, agricultural and earth-moving machines, trucks (fire-fighting, waste collection, trailers, with jibs, etc.), lifting equipment, etc.

The structure of the Group is very complex and originated by a series of acquisition of companies operating in the same sectors, including the production of parts and components, as can be seen in Figure 2.3.

After Interpump Group was listed at the Milan Stock Exchange, in 1996, 25 companies were acquired to integrate product portfolio, strengthen the global competitive position, and strengthen and widen the supply chain.

The supply chain

The Interpump supply chain is very complex and includes raw materials, semi-processed and semi-finished products: containers, boxes, pallets, carters, lids, crankshafts (up to one thousand horsepower), warheads and motors.

Interpump also takes advantage of contractors to which it gives material to be subject to specific processing stages not realised by Interpump itself.

Interpump operates on a world-wide market, and hence it needs to resort to trading platforms such as General Pump, a company belonging to the group and active in the US market.

Customers and orders

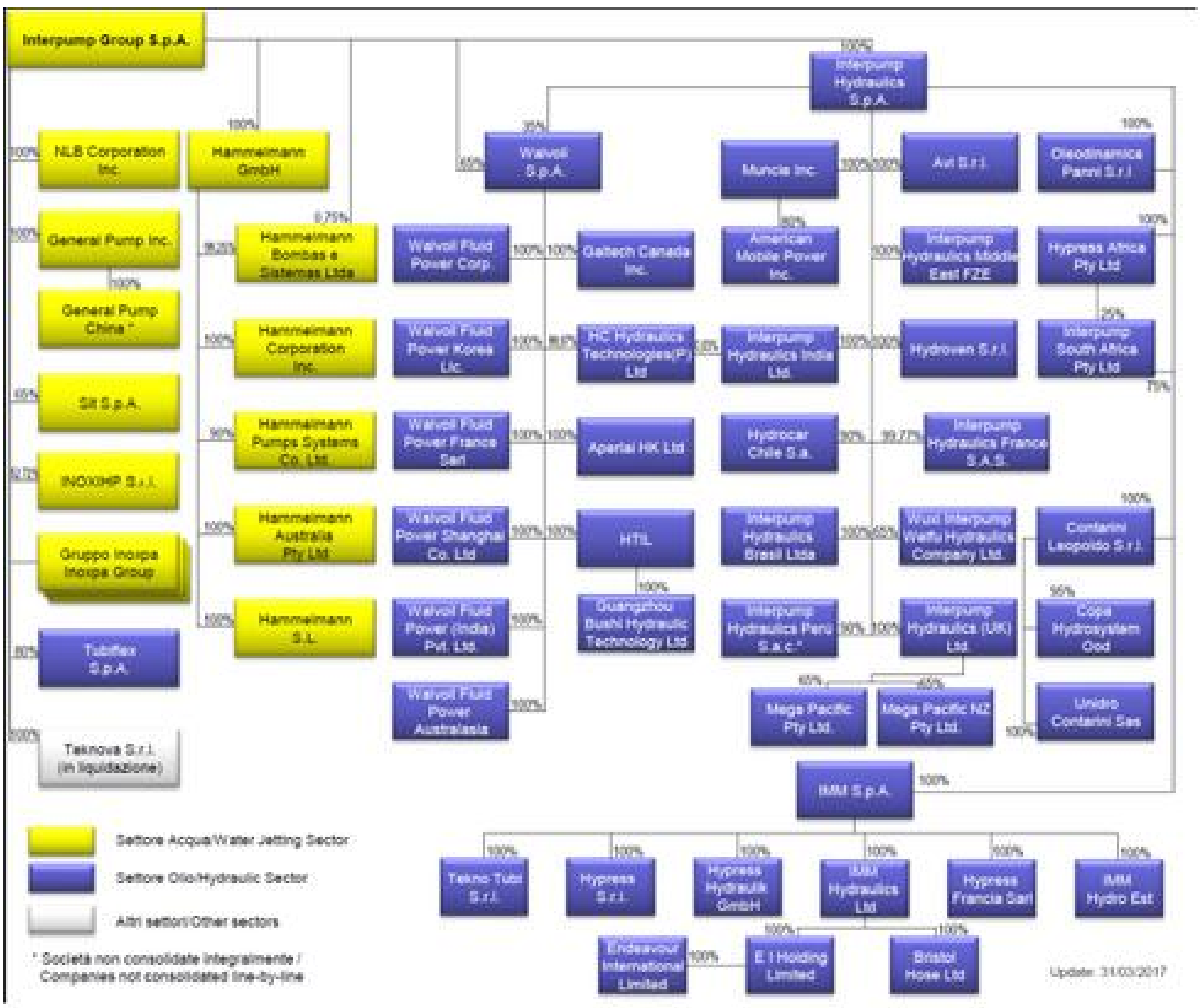
The main customers are Jhon Broocks, DiBo (Belgium), RQM, Barami, NLB, etc.

Orders acquisition and handling are up to two commercial managers and 4/5 area managers, as well as front office corporate executives who receive orders via email or phone and enter them into the system. Since May, 2014 Interpump uses Microsoft AX ERP system, which allows performing many business functions.

The adoption of Microsoft AX

Interpump Group adopted the new ERP system to integrating and harmonising the management of activities in all societies and plants of the Group, and to standardising processes. Interpump

Figure 2.3: Interpump Group



has production sites not only in Italy but also in other countries, among which USA, China, India, Brasil, Romania, Bulgaria, Germany, France. Business locations can be found also in Canada, UK, Spain, Chile, South Africa, Australia and New Zealand. For this reason, the Group needed to implement an international ERP system, starting from Interpump China. Interpump China, located in Wuxi, in the province of Jiangsu, needed to implement an ERP system allowing central control from Italy solving problems of communication, due to the Chinese language, of data transmission between the Chinese and the Italian plant, etc.

Dynamics AX made possible to build an international ERP structure thanks to complex languages management architectures and to the support for industrial structures with multiple headquarters in different countries; in this way, the system allows worldwide centralised management, and hence control, of production. From the industrial point of view, the applications of this systems are manifold: warehouse and logistics management (both inbound and outbound); demand forecasts; product mix; serial number tracking; e-Procurement; e-Commerce; orders; HR management; planning; reporting; diagnostics and analysis systems, etc. After orders entry, it is the time of production planning (by delivery plans) and materials availability check is performed: everything is managed via AX system.

AX in Interpump: production process planning

Materials availability check is done by automatic warehouse management. Supply priorities are signalled by codes in different colours (e.g. red for urgent supplies) updated daily. The list of orders is then managed by the purchasing department.

Al departments are connected through the informative system; in particular, planning is connected with the warehouse. Planning passes weekly production plans on to each department head, both electronically and on paper.

Even if the Group tends to make warehouses as lean as possible, there is one with a capacity of 10 thousand pumps.

The issue of supplying materials to the production process sometimes turns critical: some downtimes took place due to lack of materials. These issues can be contained thanks to extremely high flexibility which allow to go on to other productions. To do so while keeping costs low, a consignment stock area – i.e. a supplier's warehouse – exists since two or three years.

The machines department

The first stage of production takes place in the machines department, which receives raw components destined to workstations. At the beginning of the shift, a dedicated worker finds a production instruction file, printed on paper, with the batch number and the quantities of pieces to be produced. The department head, instead, is equipped with a PC allowing to monitor the whole production cycle.

Before finishing the shift, the dedicated worker must record – with date and time – the number of pieces produced and of scraps, and hence the total number of pieces processed during the day. The recording is done electronically by using a bar-code reader and entering the employee code (badge), the number of hours employed, machine stoppage times and the corresponding reasons.

The badge being required might entail issues because the company knows that case and hence could change the data entered by a worker. It could be considered a cyber-security problem, not for the company, but for workers' rights.

The system allows for real-time production progress monitoring: each machine automatically records the start and end of each processing stage, which is immediately available to all administrative departments.

Implementing the new ERP system introduced a machine stoppage recording system for prearranged reasons.

The cycle time of these machines is between 20 seconds and 30 minutes, according to the instructions given to machines and to the different scripts: as it was for Comer, il workmanship is fully constrained by machines.

Four software designers are in charge to program machines. The scripts are then saved to the machine itself; they are launched by department heads via PLC (Programmable Logic Controller), while a dedicated worker takes care of machine equipping and operation.

The machines constraint

A relevant source of working conditions worsening was the fact that 7/8 years ago each worker operated one single machine while, currently, she operates two or three. The constraint represented by machines, their times and productive capacity, appears again. Quite often, it is hard for workers to keep up with machines. Those who cannot are subject to relocations, or relocation threats: "we are subjected to a genuine stalking; in the machines department this happens very often."

Working times, therefore, are given by machines (particularly, by automated ones); the technical office then records machine times and fills in a control form. Even in the presence of automated machines, workers have to perform many tasks; "workers operating certain machines ... cannot stand still for a single second. [...] Because they are loaded automatically, and because they have to operate two or three of them."

"Robotisation introduced the scientific implementation of this system, because in theory a robot never stops. [...] when a machine is started, it never stops."

Materials receipts

Machines are equipped with a produced piece counter, and dedicated workers are required to perform self-control. Produced pieces are then brought to the materials receipt department, where they are recorded and entered in the AX system. In this way, information is transmitted to the warehouse and hence can cover the planning needs to supply assembly lines.

Critical issues

Workers reported structural problems like the lack space for warehouse enlargement and of tools in the logistics department. More generally, they reported lack of investments.

The packaging area is equipped with eleven monitors which are not in use dynamometric screwdrivers were introduced only after many complaints by workers, because the company considered them to be too expensive. The company never mentioned investment projects connected to Industry 4.0 to workers' representatives: "in general, information was richer before, now we, as workers representatives, are provided with no information."

Problems seem to arise also in labour organisation, which the company would like to manage by means of increasing flexibility and of temporary workers during peak times. Moreover, the company has no maintenance workers, so that this activity is performed by external contractors.

Interview with the Plant Director

According to the management, since Interpump has as its main objective continuous product improvement and strengthening its leadership in the sector, Industry 4.0 is an area of vital interest, also to keep competitors distance ("since everybody copies us").

In order to endure competition, to keep or expand market shares, the company needs to continually design new products, which requires technologically advanced machines to keep high-quality standards.

Also this year, new investments were realised or planned in new machines and automation, to improve quality control as well. The Government Plan for Industry 4.0 did not change Interpump's investment strategy, which follows a specific path since years; however, tax benefits were welcome. The management opinion of the law is positive, even though it came too late: "this law gives a boost, but it probably came a bit late, Germany started 2011 [. . .] and six years are quite a lot of time."

According to the management, the companies provide "very careful" worldwide commercial services, able to anticipate market demand and communicate effectively with the Headquarter.

Over the years, Interpump increased its production volumes, product catalogue and employment levels: the investment plan, therefore, intends to follow this growth.

Departments in a single plant are connected, as well as different plans, in order to have real-time monitoring and response times.

Thanks to this connection system, machines can be operated remotely; hence, the Group decided to buy machine equipped for remote access, including tele-assistance service by part of the suppliers.

Connectivity concerns the most technological area of the plant – where machines are located, to which the great majority of investments were devoted – as well as the connection between plants and "the Head Office, in order to mutually cooperate. People in charge of the various plants can enter our system and give instructions."

The informative system also provides for data collection. In this way, data production can be monitored in real time and data can be immediately elaborated.

In 2014, Interpump realised "a revolution. [. . .] Our informative system was outdated. In 2013 we felt the need of a new and modern operative system, and hence a great investment was approved. The time had come to take a step forward, and it was taken in 2014."

The system introduced in 2014 is the latest version of Microsoft AX, defined by the management as "a modern tool with many implemented applications, which allows managing maintenance, administration, working cycles, the collection and elaboration of data concerning productivity. [. . .] It extended the possibilities concerning security, it manages schedules, electronic document, etc."

Installing the new system implied a relevant change in working methods: “employees had to adapt to the new system, [...] that’s why we keep them apprised in the field of information technologies.”

These investments were indispensable to manage big data and “to get a timely management of the plants. [...] We always make new investments, we have always made them. [...] since nowadays it is important to use high-quality modern machinery, an informative system able to deal with this kind of machines is absolutely necessary.”

“The R&D department also designs new products requiring with lower and lower degrees of tolerance. Hence we need machines which can deal with this aspect.”

Interpump has a very wide supply chain: “we have an enormous number of supplier, the great majority are Italian, [...] because we are an Italian group, locally rooted, and our President looked to the area as well. [...] However, we also have suppliers, from the rest of Europe, for instance from Germany, [...] but we do not resort to suppliers located in certain areas, we need technologies of a certain level. [...] We share supplier with some German affiliates, our supply chain must be certified and traceable: our sector is strictly regulated and that’s why our suppliers are mainly European, and especially Italian. They provide us with everything: raw materials, raw components, patterned components, etc. [...] Many of them are with us since years, [...] we don’t look for low prices, but for quality, [...] otherwise we would take risks.”

Overall quality of a product also depends on supply chain: “our suppliers provide complete product technologies, traceability, information. They contributed to the company’s achievements.”

2.25 GRANITI FIANDRE – CASALGRANDE (RE)

Graniti Fiandre produces ceramic tiles for coatings (floors, walls, etc.)

The main raw material in the whole production cycle is soil; others are dyes and inks. Machines are supplied by companies specialised in the realisation of machinery for this sector, such as SACMI and System.

Production organisation and informative system

The organisation of production starts form orders acquired by business premises located worldwide and transmitted to the plant, where Planning departments take care of them.

Old fashioned warehouses (where great quantities of materials and finished products were stored) do not exist anymore: now, finished products are immediately delivered to customers.

The company has its own informative system, internally developed to meet specific needs and to perfectly integrate the different business functions. In this way, the company can control, plan and track the whole production process. The informative system allows communications among all units of the Group, located all over the world.

Planning designs the production cycle as a continuous flow, with scripts that give instructions to machines.

The process always starts with the creation of a production code, issued by the planning department. Everything else is associated with this specific code: soils to be used, press functioning parameters. The whole ceramic sheet shows the processing code under which all production stages have been recorded.

The code is managed digitally; machines are equipped with product processing files providing for parameters of pressure, speed, weight, etc. In other words, the production code is associated with all different actions to perform and machines and tools to use.

Traceability is also granted by the fact that finished ceramic sheets are provided with a code which can be read by logistics with a sensor produced by Siemens; this code embeds product history and identity card. The management of the logistic department is automated with AGVs; the system knows that pallets have to be withdrawn, and AGV automatically start moving.

The management system is also company-specific and is used for production planning and for production stages traceability.

Grinding, mixing and atomisation departments

In the grinding department, two continuous mills produce the bases and colour them. In this way, the two main bases for the cycle to start are prepared. Automatic mixing follows, to get the various coloured mixtures to be subject to atomisation, the following stage.

Concerning traditional ceramic production, where each worker was dedicated to one single facility, now every worker operates more than one in a single working day; for instance, a single worker could operate two mixers and two atomisation machines.

Mixing is performed by a worker launching a script; the base is transferred to tanks under the atomisation machine, where mixing takes place. Department heads save scripts to be launched to the PC located on the machine board.

The functioning of continuous mills also follows a script providing for the use of different materials in different proportions. The same holds for atomisation machines; scripts give instructions on how to dye the three available bases according to the final product to be obtained. Scripts are already set, they just have to be launched.

While processing materials, machines produce data which are collected by on-board computers and hence by the informative system (in real time); such data are also used to reset them. Moreover, the informative systems signals problems, failures, and machine stoppages.

Workers, therefore, are only in charge to launch scripts programmed by technical offices.

Atomisation machines are activated by dedicated workers in a control room: the department head is equipped with complete processing instructions, which divides into sub-instructions for workers.

A conveyor belt then conveys atomised material a silo, where it is stored. Department heads are in charge of choosing the silo according to the specific kind of atomised material to be stored, since each one is associated to a particular final product; materials will then be taken from each specific silo to realise the corresponding final product. Silos are located above the presses department.

The presses department

This department is equipped with line and on-board computers.

The line PC provides for the number of pieces must be realised for each shift, for silos and corresponding stored materials description, for the exact composition of each mixture and hence for the silo storing the corresponding materials to be taken.

The production worksheet is defined by the matron, then goes to the on-board PC located beside the press. Production settings take place by selecting the silo storing materials associated to that specific production; the machine, while working, records quantity produced and functioning parameters, data which are then saved to the on-board computer.

If a worker makes a mistake in launching the script to start the machine, she receives an email from the server singling out the specific error. The same happens for cutting, which is operated by setting the corresponding parameters via the on-board PC; also in this case, a counter records the number of cut ceramic sheets and monitors productivity.

The dryer also works on the basis of specific scripts, set by the department head; in this case, the worker only has to launch the correct script, already loaded to the machine.

Enamelling and digital printing

The enamelling line is a hundred metres long and provides for the intervention of silkscreen rollers or cabins (whose functioning is similar to that of an airbrush) by a script launched according to the manufacturing program.

The digital machine lays the inks according to graphic files (drawings, pictures, etc.) selected by the worker.

During these activities, a computer fitted to the department verifies the functioning conditions of all machines and records them in real time. A tablet is also used by the dedicated worker to record realised production and machines functioning; data are then collected by the informative system. This data collection system configures itself as a system to control working performance since it records data about workers and pace of work.

Plants remote control and connection

People in charge of the production can remotely control machines and the modification of manufacturing scripts. For instance, if a wrong value is entered, they receive an email signalling the mistake. The plant dedicated to cutting is equipped with the most technologically advanced machines, whose maintenance takes place remotely by the technicians of the companies which supplied the machines themselves.

When production stages of competence of the plant are concluded, pallets are taken by AGVs and managed according to instructions given by the sanding and cutting-packaging-delivering plants. When the sanding plant needs a batch, call for it and AGVs collect pallets according to these calls (received via the Group informative system).

The last two stages to get the final product are therefore sanding and cutting which, as specified above, are performed in two different plants.

The order for a specific final product to be obtained is what determines the whole production process, giving instructions to the various departments for them to realise all necessary processing stages to comply with it; again, the final order provides instructions to logistics through the sanding and cutting plants.

Automated logistics

The cutting plant is extremely automated, but it is forbidden to visit it is even to customers, since because a provision exists for absolute confidentiality. Once AGVs loaded the cutting machine, and the latter completed its process, the ceramic sheet is loaded to the selected line.

After checking the outcome, AGVs bring it to an automated packaging platform. After packaging, the AGVs take the product to a vertical warehouse.

When the time comes for the pallet to be delivered to the customer, AGVs electronically receive the order to take that specific pallet and loads it to two trolley drivers who in turn load it to a truck ready to deliver the order to the final customer.

The high degree of automation of logistics strongly influences employment levels: there are only four workers, two for each shift, in charge of logistics tasks.

2.26 COMAU – GRUGLIASCO (TORINO)

Suppliers network and customers

Parts and components are purchased from external suppliers because the internal department processing raw materials does not exist anymore. Parts and components are then stored in the warehouse and managed through SAP with an online system taking advantage of barcodes, which has been introduced in the last year.

Hence, Comau only assembles components produced by external suppliers: gearboxes, bearings, wirings, pliers, etc. These components come from Italy, other European countries, Japan and China. Materials are ordered once an order is acquired by Comau; they are stored in the warehouse and associated with a specific code which is then used by the various production departments to request them.

Orders are met partly by internal processing, partly using external contractors, which are taken advantage of both for design and for production. The main customers are FCA, Daimler, Jaguar, and the automotive sector in general, and foundries.

Robot

Designs of the robot to be produced are transmitted electronically to the people in charge of the different production areas, and are also available to workers.

Components reaching the different workstations are provided with the corresponding assembly schemes available to the dedicated workers; assembly kits are set up by internal logistics, according to the kind of machine to be assembled.

Comau does not work with traditional production lines; each worker has its own workstation and works as a craftsman, with her own specialisation.

Assembly of robots takes place in different areas. In the first stage, bases are assembled with electrical torque meter wrenches – an investment made by the company to assist electrohydraulic systems – and are then moved with conveyor chains. Working orders are acquired on a printed paper, but workers in Comau do not even need them because of their huge experience.

A trolley provides each workstation with parts and components to be assembled; at the end of each operation, the dedicated worker uploads its closure, and the progress to the following workstation, to SAP, by reading the corresponding barcodes. The reader is connected to a central unit taking care of the whole production area and sending data to a centralised system; data are then available to the dedicated office. The second production stage consists of assembling the body of the robot and other details. The body is previously assembled by workers in another workstation: some processing stages are carried out at the same time in different places. The wrist, one of the more complex details of the robots, is assembled elsewhere.

In the last stage, the arm of the robot is assembled. This is done with manual tools except electrical screwdrivers, whose introduction was requested several times by workers.

After the mechanical part is assembled, seven workstations are in charge of assembling the electrical part; at the end of the process, it is connected to the control unit which, after the upload of the corresponding testing scripts, a test is run. Also in this case, assembly takes place with manual tools. Robots are also provided with the software.

The implementation of WCM was limited by the intervention of union representatives for job security, who won an undertaking that each production stage cannot be shorter than 30 minutes. A complete wrist requires at least four hours to be assembled: for this reason, the company can hardly impose shorter times.

Robots assembly is quite standardised, the only variations being the final setting up of wrists themselves, which can be equipped with a welding plier, a painting mask, or a moving tool.

Processing modules

Processing modules are fiv- axis machines for the production of crankcases and cylinder heads. They use linear motors (Siemens) and take advantage of a controlled tools warehouse. The main customers are companies in the automotive sector: FCA, PSA, Donfeng, and formerly Hyundai. Processing modules are also provided with the software. However, their assembly cycle is partially different from that described above. The assembly of one single machine requires a team of two workers and one week. The components to be assembled include the base, z (longitudinal) axis, y-axis, spindle, rotating table, linear motors, and the external structure.

The machine is then electrically lifted and grounded by a crane.

The workers of the dedicated department realise all electrical connections, while ICT technicians upload management software and implement PLC, and the mechatronic team takes care of geometric setup. The last stage is testing. All installed software is developed by Comau, with except PLC software which is provided by Siemens.

Since Comau produces very complex machines, and that testing is also a very complex procedure, manufacturing times are quite long.

Body Welding

The Body Welding assembly process is similar to that of robots. Workstations receive assembly kits from suppliers; workstation teams are made by two mechanics with an electrical and a fluidic. The final product is a plant used for the assembly of car bodies; they are made of a tunnel (through which semi-processed cars are fed) and of robots taking care of the different processing stages (e.g. welds). Sometimes robots are provided by external suppliers, such as Kuka, upon request of the customer. The different parts of the plants communicate with each other thanks to software provided by Protea.

Industry 4.0 and outlook for the plant

At the end of October 2017, the plant located in Grugliasco employed 1204 workers, of which 725 professional, 318 white collars and 161blue collars: the great majority of manufacturing activities was externalised. Over time, a great deal of expertise was lost, because Comau did not create the conditions for transfer of skills. The company is not planning new hires or huge investments; on the contrary, it decided to acquire new orders only according to available workforce.

Workers are quite worried about Industry 4.0: "we produce Industry 4.0 technologies. We should have plenty of orders, but this doesn't happen. [...] The robotics department produces one robot per day, while in former times it used to produce 7/8." The powertrain sector also faces few orders, while body welding seems to show a better performance.

Such an asymmetric workload implies that workers are moved from one department to the others according to the company's needs; this, of course, has consequences on workers' skills: "if I'm transferred into body welding department for one year, and then I have to go back to robots, I have some troubles doing what I used to do because it's been a while."

At the time being, Comau's order book does not include many Industry 4.0 machines. In the show room there are some designs, such as the Cooperative Robot, the AGV trolley for logistic activities, robots with cameras to recognise components.

As regards Powertrain, industrial projects are declining, and one has the impression that in the future production machines are bound to disappear, while workers will be in charge of maintenance and assistance at the customers' premises (while machines will mainly produced at Castres, France) at Mirafiori, Teksid, FTP, Iveco. Some other workers will be in charge of machine revisions. Comau will transfer the production of new technologies to the Powertrain Machining and Assembly plant at Castres Cedex in France – formerly Renault automation, competitor of Comau in the production of processing modules. The French plant became the main Powertrain producer for Comau. The plant in Turin, on the contrary, lost productions such as cast-iron bases, huge truck motors, etc. (moreover, two plants in the province of Turin were closed); it rejected a huge order from Donfeng, and other orders (Waieroid) were lost; it is not interested in investments for new products, such as multi-spindle lathes machines.

Up to 2006, the plant included an R&D office; currently, R&D activities are allocated in the five huge dedicated company centres worldwide.

The presence of premises in other countries is a cause for concern: if an automotive company in Brasil needs a Body Welding, it is realised by Comau plant in Brasil. Something similar happens with Ford, whose orders are now realised in the US contrarily to what happened some years ago.

The company announced an investment plan for 20 million euro, to be realised within 2018/2019, aiming at modernising plants and technologies by the 'Industry 4.0' plan, including an appropriate training plan. The agreement provides for periodic checks.

Technologies and tools

As to tools used by workers, the assembly line for robots is equipped with digitalised screwdrivers, which can detect applied force and the number of screws to be tightened and ensure that they have been tightened correctly. Moreover, the company is testing some other innovations (in the assembly of forearms and wrists), such as Wi-Fi wrenches. Logistics is managed with SAP, through which all warehouses are connected and managed via PC.

Production departments are provided with PCs with all production scripts; according to the kind of robot, the corresponding script is called, and then assembly takes place. In the robotics department, workstations are equipped with monitors stating the various tasks to be performed. Once the procedure is concluded, the dedicated worker electronically submits it for the following stage.

Currently, however, the monitor is not operational; moreover, workers of production departments are not trained to acquire skills in the field of digital innovation.

White collars take PLM courses for materials encoding and management; however, confusion reigns over supplies and logistics, so much so that daily meetings are necessary to check availabilities and possibly proceed with purchases.

All supplied components are provided with a barcode, are recorded and stored, but there is much more confusion than in the 1990s (when the quantity of materials to be managed was three times as much); at those time, each part and component was associated with the corresponding order and easily identifiable in the corresponding warehouse (electrical-fluidic-mechanic).

Working performance traceability

Working performance is tracked through a paper-based system, through the compilation of a specific sheet for each hour worked, where stoppage times and the corresponding reasons must be stated. In this way, the company checks how much time is dedicated to the realisation of the different products and computes the corresponding production costs. These data are then uploaded to PLM by white collars. This also creates conflicts between the people in charge of different departments for working hours imputation (e.g., in order to lay the blame for possible delays elsewhere). Industry 4.0 could automatise the task of uploading data on working hours and hence endanger these jobs.

In the future, these technologies could automatise worksheets as well (e.g. they could be automatically available from monitors or tablets, digital watches, etc.) and hence automatise the recording of production stages, working times, time stoppage and the corresponding reasons, etc.

According to the company, the management of worksheets is dictated by WCM and hence there is no room for unions to bargain. According to FIOM, since worksheets are not provided for by the contract, workers should not compile it.

According to what provided for by WCM, since one year and a half, there are daily 12/13 people meetings, and at 8,30 a.m. notice boards are compiled with the program and progress of the working day. Therefore, there is no reason for workers to describe their daily activities.

2.27 FIAT POWER TRAIN – TORINO

In the restructuring of FCA Group, FPT has been placed in CNH together with New Holland and Iveco.

FPT has three kinds of productions: motors, axles-transmissions, gearshifts.

FTP produces for small (Daily van), medium and heavy (Astra, Eurostar) vehicles. It is the only plant in Europe producing transmissions for Iveco.

Gearshifts

It is the department experiencing the major difficulties connected to production and HR management. This also happens because Daily van (Iveco) employs a kind of automatic gearshift which is not produced by FTP. Hence, the great majority of parts and components are provided by external suppliers, located both within the territory and elsewhere. To keep this department, the revision of gearshifts, formerly externalised to the UK, has been internalised again.

Axles

It is the department with the most out-dated technology, and this is a bottleneck in the way towards lean production. The premises of Iveco located in Suzzara and Madrid, which are customers of FTP, require lean production to eliminate inventory costs. This creates problems for the management of the plant, because the mechanical line lags behind assembly, and workers have to go into overtime.

In this department, due to FCA financial strategy, very few new investments were made.

Motors

In this case, more than 30% of total production is sold to customers other than Iveco.

As regards NEF motor, some mechanical components, such as crankcases and motor heads, are realised internally, while other components are provided by external suppliers; in the case of the F5 motor, all parts and components come from external suppliers, and the plant is only in charge of assembly. The only planned investment concerns a different way processing the crankcases to reduce oil and gas consumption. Another problem is represented by logistics: il WCM and just-in-time implied a modification of supplied management close to production lines. The process is complex, also because it requires separating the processing of crankcases (rods, pistons, etc.) and heads (valves, springs, etc.); the two parts are then assembled and afterwards oil, water, etc. supply groups are assembled as well.

In theory, AGVs should automatically supply the necessary parts and components, but the plant is old, and there is a lot of jamming going on.

SAP

The warehouse management system is SAP; the CLIK system is also used, which implies components to be recorded via tablet provided with an optical reader which reads a bar code; the same code is read whenever a component is required by production lines, and a monitor shows its location. In fact, due to understaffing, logistic services is extremely malfunctioning. Motor check lists were outsourced to two external companies, and take place at the end of the process, with the risk that many problems are not detected.

Moreover, the lack of parts and components often implies temporary interruptions of certain productions.

Work organization

Orders are received from external customers or Iveco plants. Production is planned monthly, but it is often modified weekly, also because the production mix implies modifying machinery set-up and workers' workloads. Order delivery times also depend on external supplies, especially those coming from suppliers located abroad (Turkey, Germany, etc.).

When the assembly line receives a production order, it demands all necessary parts and components to the logistic and mechanical departments.

In theory, production orders are received electronically, but in practice what is actually taken advantage of are personal relationships, experience, and a deep knowledge of the plant by part of workers. The order is electronically sent to the head of the service department PC, with the detail of every necessary part and component; in collaboration with the sales office, materials provided by external suppliers are ordered, while production orders for mechanical parts (crankcases and heads) produced internally are sent (both electronically and on paper) to internal production departments.

Clearly, the mechanical department has to face the problem of the production mix, which is done using CNC machines provided with crankcases and heads reading systems allowing to perform the necessary production stages. However, production mixes to be realised just-in-time create many problems, especially in the management of the daily mix.

Machines in use in this department are part of transfers and closed-loop lines. When raw components are received, they are loaded to two workstations for preliminary processing, and then transferred to other workstations and machines for the following production stages. All machines are CNC machines with CM on board PCs. Hence, machines are automatically activated by a reader which reads the codes associated to each piece to be processed and launches the appropriate instructions. The operations to be performed by each machine are available on CM, provided with a specific software which elaborates the reader's output and activates operations execution.

The software is available on PLC and CM, i.e. electrical substations which are programmed at the beginning of the cycle; maintenance workers and electricians are in charge of electrical components, while an external company is in charge of managing software. This external company is Protea, which supplied machineries in 2010 and now is providing software assistance as provided by the contract.

The system of Production orders are sent to all workstations, machines recognise them thanks to the reader and machines recognise (reading according to the holes) the pieces and proceed with the workings. The components reading system with which each machine is provided is set-up at the beginning of the cycle.

Transfers perform various operations. If during the cycle a machine halts, workers have to manage the rest of the cycle on the remaining machines (with variations or recoveries) to prevent the complete halt of the overall cycle. Operations on crankcases are performed by 15/16 machines, each including ten processing modules; each worker operates at least two or three machines at the same time, with the obligations to perform own-checks. Workers have to check that plants are functioning properly, to restore machines, to change tools, to check output quality.

SAP is the system for warehouses management and inputs supplies.

AGVs are used by the assembly department, but not by the mechanical one. Internal logistics is not organised in a linear fashion: there are intermediate warehouses and non-linear paths.

Machines in the mechanical department only record the last stage performed along the transfer; translation rods transfer materials from one workstation to the following one. At the time being, a system to track each single stage does not exist: this represents a critical issue from the point of view of the quality of work, because in case of problems it is impossible to immediately single out the exact stage at which they emerged, but it is necessary to spend time looking for it. On the other hand, this implies that the company does not implement a real-time control on each single production stage. The various variations of finished motors do not have a strong influence on the degree of variance of the product mix; the latter depends on the different single components a motor consists of (electronic components, number and kind of cylinders and valves, structural parts, etc.).

Crankcases and heads converge to the assembly department, where they are put together. A trolley operator packs up finished crankcases and brings them to the assembly line, where the crankcase and the corresponding head are automatically picked up by a portal. Portals consist of Comau robots or by three-axis lifting equipment. Portals run on tracks; a mechanical arm picks up the component and then puts it down; it is activated by a NC system. Components to be assembled are picked up through a laser numerical marks reader, providing for the correct crankcase-head combination, the final product to be realised, and the final assembly plant of destination. Actually, the latter reading – associated to the final destination – is not active yet; the reader system, therefore, identifies only a part of the possible variants. The marking system is at work in the final part of the assembly line only, while, according to workers, traceability would improve were it at work from the very beginning. In this way, in fact, it would be easier to exactly locate any single component in the plant.

The portal is located on a closed-loop line. It picks up crankcases and places them on a conveyor belt reaching the various workstations, which assemble crankshafts, valve gears, injection pumps, and in general all internal components (variants) of a finished crankcase. For assembly, workers take advantage of various tools such as hoists. Some workstations are automated, some are provided with machinery, some are completely manual. The cycle time of the line depends on automated operations: for instance, the crankshafts assembly is automated, and hence times are determined by the machine. In theory, cycle times of different workstations have been computed to keep it (one minute and 13 seconds for each operation); actually, the production mix makes it impossible to keep to these times. These lines imply a smaller effort by part of workers than traditional production lines, with the exception of a few workstations.

The realisation of heads goes along similar lines. When both parts are completed and assembled by an automatic machine, a conveyor belt brings them to dressing. The dressing machine takes the assembled motor provides it with the last components to be assembled – oil, water, etc. supply groups, received from the preparation department – in a basket. Originally, the idea was that of having an automatic machine autonomously reaching the workstations actually assembling supply groups to the motors. However, this would have required a huge investment and the company decided to save money and give up on a software which would have ensured a better control; as a consequence, transport to and from assembly workstations takes place manually. After the final assembly, motors are tested and sent to surface coating department. After this stage, they are ready for delivery.

Industry 4.0

FTP started a discussion about Industry 4.0. From the point of view of safety, robots collaborating with workers are supplied by Comau, and are provided with extremely advanced security systems. From the point of view of traceability, FTP seems to lag much behind the most advanced experiences, with pros and cons. The company implemented some trolleys, supplied by Toyota, provided with sensors able to detect the presence of human beings within a certain range; in their turn, workers must wear sensors which can be detected by trolleys. This tool, which the company presented as a safety system, induced workers representatives to open a discussion on video surveillance systems. As usual, workers representatives asked to introduce a clause to ensure that these data will not be used to control or penalise workers.

A possible additional field for further Industry 4.0 investments could be the preparation of parts and components for production and assembly lines. Thinking regarding WCM and lean production, these operations should take place near the lines which they should provide with parts and components ready to be used. This could be done by robots able to select the correct components to be used and give them to workers in few fractions of a second.

Moreover, investments could be made in the field of 3D printing, to save energy and raw materials consumption in the production of crankcases.

CHAPTER 3

Conclusions: what did we learn?

3.1 GENERAL OVERVIEW

Our main hypothesis of the coevolution of technology, of the industrial and organisational structure, of business models and social and public institutions, has found full confirmation.

Regarding the first two terms – industrial and organisational structure technology – case studies are enlightening. None of the companies interviewed developed digitisation processes without being closely connected with reorganisation processes, as an IMA manager says: "As far as integrated systems are concerned, we are very distant from each other because each level below the master level must be digitised and integrated and therefore this requires both the creation of CRM systems that integrate with the design and management of data sensors."

The reorganisation concerns both the real manufacturing process and all the management and technical planning aspects. Just think of the complex problems to be solved to introduce Manufacturing Execution (MES) systems and the integration processes between manufacturing and design. The basis of these reorganisation processes is generally speaking some variant of lean production. In fact, in recent decades, many companies have adopted this standard. There are cases in which companies had inherited organisational models that were partially or radically different from the "lean" ones, and the reorganisation maintained this diversity. As in the case of the Ducati and Lamborghini assembly lines.

As far as the relationship between technological innovation and social, the institutional framework is concerned, there is a clear relationship between the presence and the strength of the union in the companies interviewed and the forms of automation developed. As well as between trade union's strength and the attention paid to training processes, the taking charge by the management of employment problems and its willingness to adequately inform and sometimes involve (Ducati, Lamborghini) workers' union representation in innovation choices. This correlation is accurate both in cases where relationships are more or less markedly corporatist and when they are more based on a clear distinction between union and enterprise.

The picture that emerges, therefore, is that of a variegated set of technological practices; a variegated set of two-way relations between the five dimensions of Figure 2.1. Not necessarily the process of digitisation is the *dominus* of change; there are those who say (SACMI) that "today, sensors are more evolved, but it is an evolution, not a 'break', while the real news is the business model. Competition is played on selling the machines even at their production cost and recovering the margins on the services that the digitised machine allows; it is no coincidence that the after-sales numbers are almost equal to those of the machines. This business model requires strong economic and financial returns."

And, symmetrically, another SACMI executive sees industry 4.0 as "an opportunity for reorganisation and improvement."

Regarding the relationship between the institutional political framework, the Italian government's 4.0 industry plan is modelling the paths of technological innovation of Italian companies with the effects that we have highlighted in the introductory section dedicated to it. The limits highlighted are due to specific characteristics of the Italian institutional framework. Besides, the culture of the management plays a role; it is not by chance that two companies owned by AUDI – Lamborghini and Ducati – have a specific way to manage their industrial relation.

On the central role, finally, of the skills and competencies, there is a broad consensus among the interviewees on both the management and workers sides.

Finally, we supported, in the position paper, that the rhetoric about radically innovative (disruptive) transformations had to be scaled down. The scale down is not to deny that there are real technological leaps, but that they are inserted on a line of technological continuity. Beyond what our position paper stated, the testimonies are very significant. The simultaneous availability of all these technologies allows, in many cases, to bring to their natural conclusion processes started, in some cases, decades before. Change the scale and power of previous processes. The most radical aspects are those related to Artificial Intelligence and its repercussions on robotisation and automation; the availability, for example, of visually fixed non-rigidly defined visual recognition systems.

One of the hypotheses we have formulated is the need to exit from the traditional scheme of the sectors as an analytical criterion to understand the differences in the innovation paths of the various companies analysed. The variety of technological practices can be reorganised by highlighting some trends, some elements of aggregation of different cases. The problem is identifying these aggregation criteria. The first and the simplest is to distinguish companies according to whether their innovative process is markedly oriented towards the production of smart products or the creation of a smart factory, or in a balanced position between the two possibilities.

On the social side, the process of digitalisation of the production process leads the way to a kind of work organisation in which all not-added-value time will be eliminated, and therefore there will be an increase of the saturation of the working time. The digital infrastructure of this process will allow a level of transparency of the activity of each employee and therefore of control on his/her performance without precedent.

3.2 IMPACTS ON EMPLOYMENT

Our approach to the possibility that Industry 4.0 and the development it is going to bring about might destroy jobs is very cautious.

According to a recent study by Frey and Osborne [2013, p. 1] "about 47 percent of total US employment is at risk" due to computerisation and tasks automation. By the same methodology as Frey and Osborne, the Bruegel Institute [2016] concluded that "the proportion of the EU workforce predicted to be impacted significantly by advances in technology, over the coming decades, ranges from the mid-40% up to well over 60%." However, studies based on different methodologies predict a different outcome; according to the Institute for Employment Research [2016, p. 4] between 2015 and 2025 in German industry "490,000 jobs will be lost while in other areas 430,000 jobs will be newly created."

Different results depend on different macro-simulation methodologies and baseline scenarios. There is no way of assessing which methodology is to be considered as superior, or whether such predictions are reliable.

Therefore, we chose to focus our study on detailed analyses of specific firms rather than macro scenarios. More specifically, rather than the issue of labour market, in terms of the balance between jobs destroyed and created as a consequence of Industry 4.0, we are going to investigate the way in which these innovations are changing labour status – new and more flexible forms of employment; dichotomy between employment and self-employment, and labour conditions. Will it still be possible to realise social regulations such as working time restrictions, health and safety in working places protection, collective defence of the interests of workers, etc?

Undoubtedly, new threats are appearing connected to Industry 4.0. Routine tasks (both in the manufacture and in administrative services) are likely to be automatised and the correlate jobs to disappear; as a consequence, medium skill jobs are likely going to be strongly reduced, which would produce a polarisation of the labour force between highly-skilled (and paid) and low-skilled jobs.

The consequences on labour conditions are going to be manifold. The above-mentioned skills polarisation might result in a corresponding geographic polarisation, which could deepen centre-periphery asymmetries in Europe. A wide range of expertise might be required even for simple tasks. Working contents, processes and environment are going to change radically. Working time is going to become much more flexible, and traditional division of labour to disappear. Job performance is becoming denser and more subject to monitoring.

So far – and it is worth repeating, so far – the implementation of Industry 4.0 technologies by companies included in the present research does not seem to imply important consequences on employment.

To be more precise, at the time being the strategy of these companies seems to be focused on increasing production and productivity without the need of new hires. In other words, the crisis brought about jobs losses associated with a decline in output; Industry 4.0 might allow increasing production, approaching pre-crisis levels, without correspondingly increasing employment levels. There is no sign, however, that redundancies and consequent layoffs are going to emerge. Of course, this means that these companies are not going to hire new employees to face turn over, even in the presence of production growth perspectives. The phenomenon, however, seems to be in line with general trends associated with labour saving technical progress, and not to a revolutionary extent. In many cases, automation implies moving workers previously in charge of automated tasks to other departments or duties.

A conclusion drawn by the present research is precisely the necessity to deepen as much as possible a detailed and rigorous analysis of production cycles, to single out all possible jobs/tasks likely to be automatised and, therefore, to jeopardise human labour.

Another consequence of the introduction of new generation machines has been the fact that workers went from operating one single machine to operating several ones (versatility).

In some cases, companies expect that fewer people will be engaged in manual activities, but discussion about this topic is, for the time being, extremely generic; the same holds for the topic of the new skills which will be required. The latter topic is of concern to Trade Unions, especially due to workers' average age. In general, the most relevant consequences on employment take place in logistic services.

The main source of unemployment due to Industry 4.0 seems to be connected to the fact that these technologies are meant to make supply chain coordination and lean production easier, also in the case of geographically dispersed production networks. It means that Industry 4.0 technology will make externalisations, and in particular offshoring, much easier – and this will probably be the primary source of unemployment, and also the main difference between Industry 4.0 and the previous waves of technological progress.

Even if many of the companies involved in the present research implemented quite a high degree of automation, it seems unlikely that this will replace human labour; rather, automation seems to be at the service of human labour – and many RSUs share a positive opinion about some new technologies implemented in production lines.

As regards clerical workers, the present research recommends a specific detailed study, since Industry 4.0 concern – and will concern even more in the future – them as well, with even more relevant impacts than on blue collars.

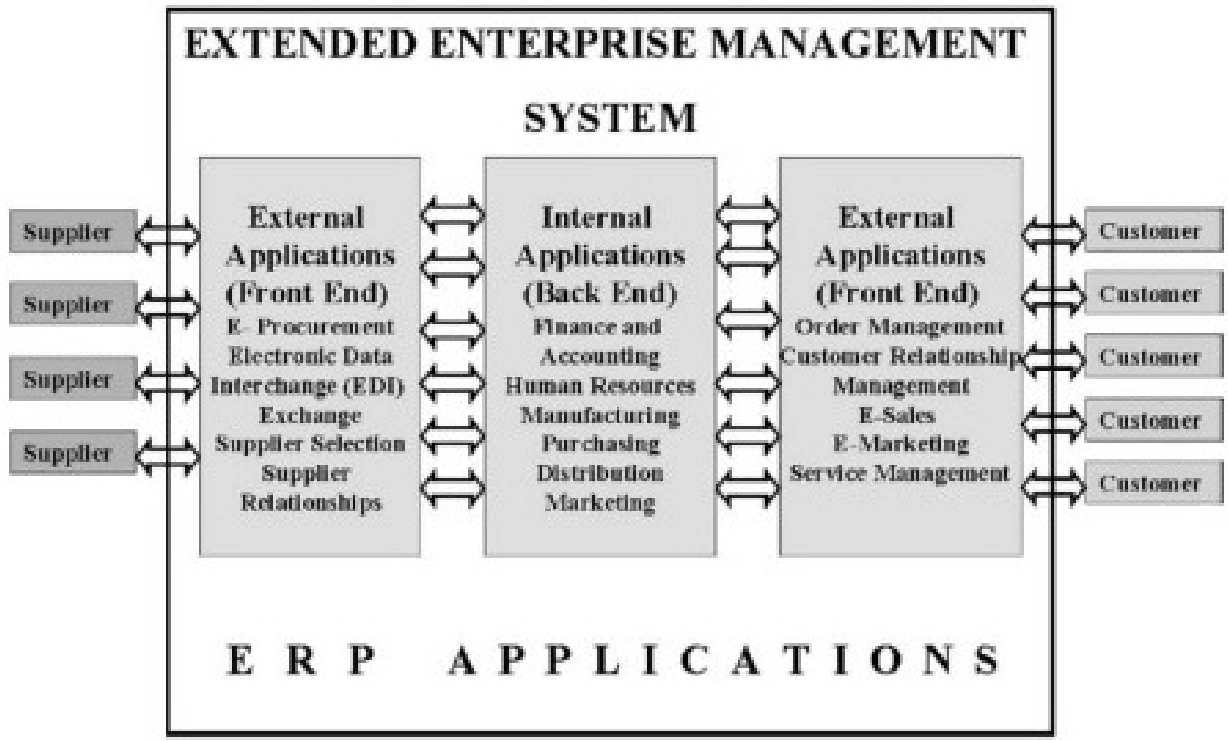
In general, it would be worth performing an analysis of productivity changes over the last years, to get a more precise picture of the extent to which technological progress has been labour saving. The evolution of productivity should be compared with that of employment, taking into the correlation with specific events such as the introduction of technological and organisational innovations, and of important industrial and investment plans.

3.3 ERP AND MES

The long quote which follows comes from *The Internet Encyclopedia* [Bigdoly, 2004].

> Enterprise Resource Planning (ERP) is defined as an integrated computer-based system that manages internal and external organization resources. These resources include tangible assets, financial resources, materials, and human resources. At the same time, ERP is an application and software architecture that facilitates information flows between various business functions inside and outside an organization and, as such, is an enterprise-wide information system. Using a centralized database and operating on a common computing platform, ERP consolidates all business operations into a uniform system environment. [...] The word "resource" in the ERP name reflects the system's intention to rationalize the usage of an organization's resources. [...] The word "planning" describes one of the main functions of resource management, i.e., planning resources through a variety of business processes.
>
> Introduced in the early 1990s, the term "ERP" does not reflect the real capabilities of the system it represents. First, ERP systems provide not only planning but also other management functions such as organizing, controlling, scheduling, reporting, and analyzing business processes. Second, a traditional approach to ERP considers it a "back-end" computerized system for managing the internal

Figure 3.1: Enterprise Resource Planning (ERP)



resources of an organization. However, the ERP has crossed the boundaries of being just a system for planning internal resources. It may often contain "front-end" applications of managing customers and improving customer satisfaction—customer relationship management (CRM); collaborating with suppliers through applications of supply chain management (SCM); and utilizing business-to-business (B2B) e-commerce. As such, this integrated system combines external (frontend) and internal (back-end) business applications and should be defined as an extended enterprise management system or extended ERP system.

The next major step in the evolution of ERP was the development in the early to mid-1980s of a new breed of integrated systems: manufacturing resource planning (MRP II). This system fully integrated materials and capacity planning with distribution planning, sale ordering, marketing, finance/accounting, and human resources. Besides planning material and capacity resources, MRP II integrated inventory with financial/accounting transactions, sales orders with materials planning and accounting/finance transactions, marketing and sales analysis with demand forecasting, etc. All inputs and outputs, analysis, and reporting were based on one centralized database system. [...] Modern ERP systems were established in the early 1990s. This coincided with the proliferation of personal computers, which replaced the old mainframe capabilities with the new client-server technology. Considered as an advanced MRP II system, modern ERP has several major differences from MRPII systems: utilization of the client-server technology and its ability to run on personal computers (clients) and powerful servers utilizing multiple operating platforms (Unix, NT, etc.); advent of ERP into nonmanufacturing companies ("enterprise" rather than "manufacturing" resource planning); and integration of MRP II applications with new business processes like supply chain management and customer relationship management. [...] The latest evolution of ERP systems started at the end of the 1990s with the introduction of Internet-enabled ERP systems. This introduction correlated again with major changes in IT systems that were signified by the Internet and e-commerce revolution. The new systems were characterized by Internet-enabled ERP architecture; new front-end e-commerce solutions; easy access to the system by employees, customers, and suppliers; collaborative planning and scheduling; and optimized operations, finance, and marketing decisions. [...]

The majority of modern ERP systems are fully Internetenabled systems. This means that communication between a server where an ERP system is installed and many clients (end-user PCs) is done through the Internet. An ERP system may comprise three main tiers: clients, applications server, and database server.

Clients are end-users that connect to the system via Internet browsers. An applications server incorporates a Web server, forms, system tools, and a variety of ERP programs.

A database server includes a relational database with ERP records. Some ERP systems have been developed with separate applications and Web servers, which would define them as four-tier systems (clients, Web server, applications server, and database server).

[...]

In many respects, ERP is a result of modern organizations' efforts in designing management information systems. Various processes of an organization have to be linked together so that whenever a change in an external or internal process takes place, the company is able to adjust all other related processes immediately and effectively. ERP systems enable this to happen, not only at the information systems level but also at the applications level, by utilizing certain principles and features.

The two main ERP principles are integration and automation.

ERP integration is based upon these items:

- A single database system operating on a common computing platform. All ERP applications would input data and retrieve information from the same database and all employees would have the same point of access to get necessary information;
- An integrated set of commonly designed business applications including manufacturing, distribution, marketing, accounting, finance, and human resources. This set consolidates all business processes into a uniform system environment;
- Integration between internal company applications and external applications for accessing customers and suppliers. ERP automation represents the ability of an ERP system to automatically process business transactions and information between different processes and functions inside an organization, as well as between this organization and its customers and suppliers. The elements of ERP automation are as follows:
- Automated business transactions. For example, these can include calculation of production and material schedules, demand forecasts, inventory levels, and production costs.
- Automatic information sharing between numerous organization functions. Data created in one application become available to other related applications. For example, a new employee input made in a human resources module may be available in other applications like purchasing and marketing, which utilize this employee information.
- Automated recording, monitoring, and reporting of the data generated in ERP.

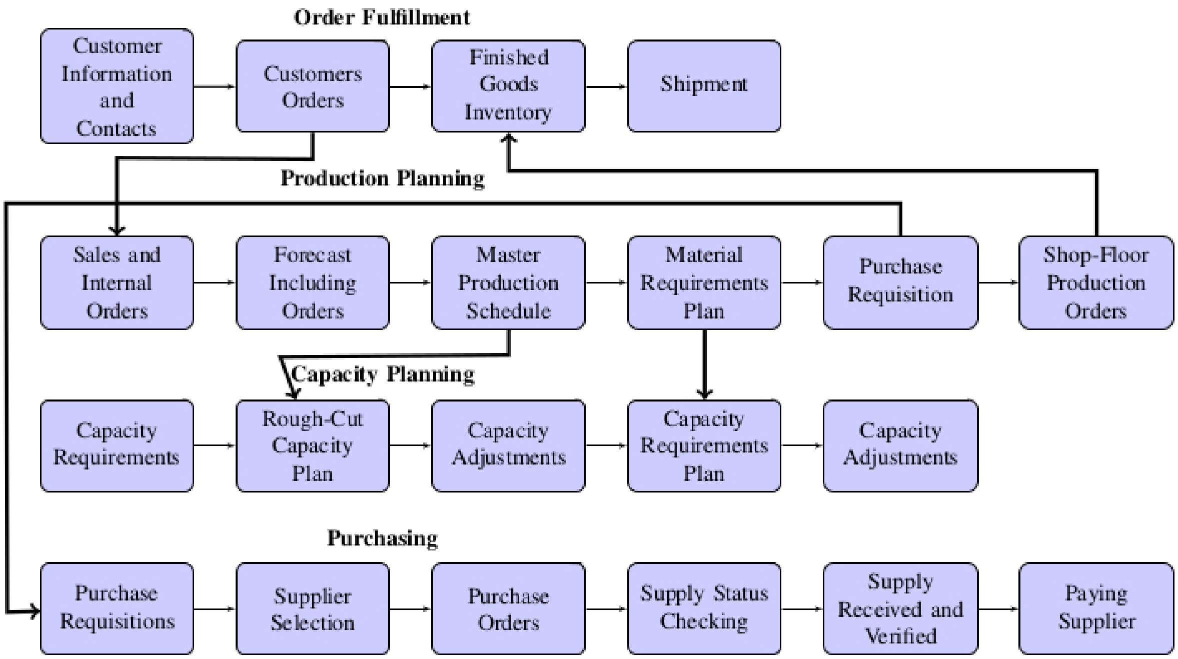
[...]

One of the most important ERP features is that it is a *process-driven system*. In contrast to individual and function-driven computer applications in marketing, finance, or operations, an ERP system integrates these functions into a variety of computer-based processes.

They represent real business processes that companies apply to managing resources, working with customers and suppliers, etc. In general, an ERP system may include a variety of business processes such as: order fulfillment; production planning and scheduling; capacity planning; outsourcing materials from suppliers (purchasing); shipping products to the customers; product costing, payments, and receipts; managing customers; selecting and managing suppliers.

Some of these processes are interrelated and dependent on one another.

Figure 3.2: Enterprise Resource Planning (ERP)



Integrating these business processes into a company's ERP system provides the necessary environment for running the company in real time with all functions being interoperable in the system.

Other features of ERP systems include:

- A *relational database* that integrates all data inputs, transactions, and outputs of ERP systems. This can substantially reduce or even eliminate inaccuracy and inconsistency of records that might have existed in separate individual databases. The Oracle database is the most popular relational database used in ERP systems.
- Company-wide access to information from a relational database. Transactions that are taking place in each ERP-driven business process may be visible, in principle, to anyone in an organization. In practice, however, the level of an employee's visibility of and access to ERP processes depends on the employee's role (responsibilities) in the company.
- *Multiple simultaneous accesses* to the ERP system by many users and in various locations. This feature may international locations/divisions and wants to integrate all business functions into one computer system. This feature also enables fast and reliable information sharing between different parts of the company.
- *Scalability*, which means that an ERP system provides adequate capabilities in the situation where the total number of users of the system is growing. This may be due to the company's expansion or to its merger with or acquisition of another company. A scalable ERP system should also accommodate a growing number of users and applications without jeopardizing the speed of transactions or the performance of the entire system.
- *Internet-based architecture* of ERP systems. From a technical standpoint, ERP systems should be flexible enough to run on *various implementation platforms* and operating systems, like Unix, Linux, and NT.

[. . .]

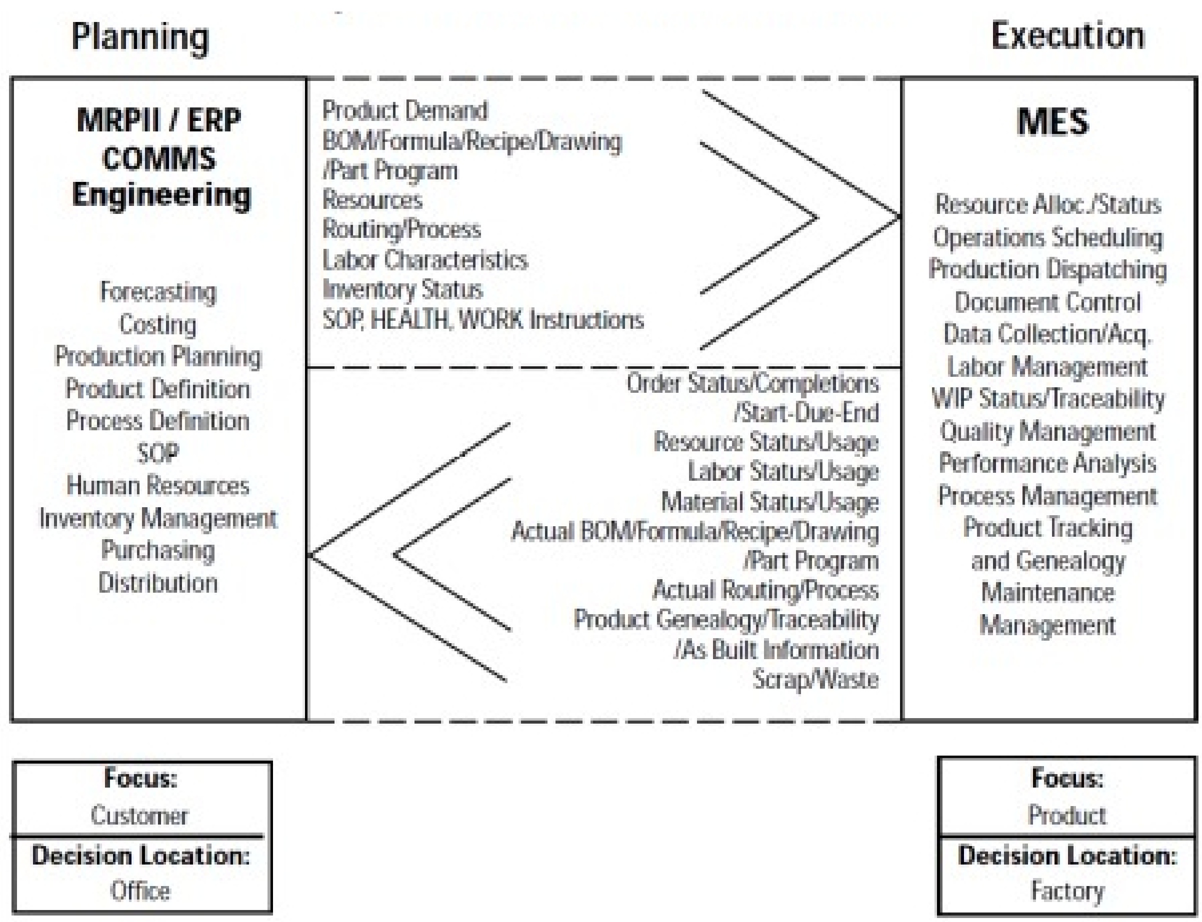
> ERP integrates a great variety of business applications. Their titles, components, and capabilities may vary between different ERP software packages. However, traditionally, an ERP system is composed of *manufacturing and distribution, financial, human resource management* (HRM), and *marketing and sales* groups of applications. In addition, an extended ERP system may include *supply chain management* (SCM) and *customer relationship management* (CRM) groups of applications. In many modern systems, the *manufacturing and distribution* applications are tightly associated with, and sometimes become inseparable from, the SCM applications. Thus, they may be considered as one combined ERP group. The same is true for the *marketing, sales, and CRM* group.
>
> Within each group, ERP applications may be clustered into three main categories. The first category – *core applications* – is composed of traditional "back-end" business applications existing in current and old versions of the ERP software. The second category – *applications enhancements* – is a set of additional applications that are used to analyze, improve, and optimize business decisions and processes in each ERP group. The third category – *e-commerce solutions* – is composed of various applications of B2B e-commerce.

What follows is taken from MESA International [1997]. This paper relates the emergence of just-in-time model with the evolution of ERP towards MES.

> By the mid-1980s companies began applying JIT (Just in Time) to solve many of their manufacturing problems. Powerful new concepts, such as "push versus pull," ricocheted throughout the industry, and MRP software developers scrambled to make their systems appear orderless. Manufacturing systems provided functionality to support Kanban environments. Practitioners and consultants alike learned to reduce lot sizes to one in an effort to achieve immediate productivity gains. Quality was king. Then two words, 'cycle time', entered into manufacturing as a focus for competition and a measure of production success.
>
> MES applications provide companies with the tracking capability to monitor the floor activities with greater resolution (hour/minute), and integrated with finite capacity scheduling to provide fast reaction to changes. It must also continually analyze activities in order to be responsive to events as they occur on the shop floor.
>
> [. . .]
>
> One of the breakthrough ideas that has occurred within manufacturing software is the emergence of synchronous manufacturing systems, MES coupled with a scheduling module.
>
> [. . .]
>
> Manufacturers want software that enables them to concentrate on continually improving this particular process. Common improvement measures used by manufacturers include quality, cost, and cycle time. MES helps manufacturers affect these measures by improving the scheduling of all direct resources that control throughput, synchronize support resources, and identify and eliminate wasted time and materials. MES synchronized with scheduling allows companies to efficiently manage time and resources, which are keys to realizing significant productivity gains.
>
> By incorporating an MES approach, a company can create an environment that streamlines the manufacturing flow and increases the velocity of production, while maximizing the added efficiency (touch time/cycle time).
>
> [. . .]
>
> Automated MES systems not only assist production people to schedule precisely but provide an electronic network for performance improvement. MES includes functions for finite operational scheduling, resources management, the dispatching of production units (jobs, batches, lots or whatever.) MES will supply automated data collection and the delivery of detail documents such as instructions, recipes, drawings and part programs to the work station. MES will also record production details and analyze performance.
>
> The main functionalities of MES are:

1. **Resource Allocation and Status**
   Manages resources including machines, tools, labor skills, materials, other equipment, and other entities such as documents that must be available in order for work to start at the operation. It provides detailed history of resources and insures that equipment is properly set up for processing and provides status real time. The management of these resources includes reservation and dispatching to meet operation scheduling objectives.
2. **Operations/Detail Scheduling**
   Provides sequencing based on priorities, attributes, characteristics, and/or recipes associated with specific production units at an operation such as shape of color sequencing or other characteristics which, when scheduled in sequence properly, minimize setup. It is finite and it recognizes alternative and overlapping/parallel operations in order to calculate in detail exact time or equipment loading and adjust to shift patterns.
3. **Dispatching Production Units**
   Manages flow of production units in the form of jobs, orders, batches, lots, and work orders. Dispatch information is presented in sequence in which the work needs to be done and changes in real time as events occur on the factory floor. It has the ability to alter prescribed schedule on the factory floor. Rework and salvage processes are available, as well as the ability to control the amount of work in process at any point with buffer management.
4. **Document Control**
   Controls records/forms that must be maintained with the production unit, including work instructions, recipes, drawings, standard operation procedures, part programs, batch records, engineering change notices, shift-to-shift communication, as well as the ability to edit "as planned" and "as built" information. It sends instructions down to the operations, including providing data to operators or recipes to device controls. [...] Storage of historical data.
5. **Data Collection/Acquisition**
   This function provides an interface link to obtain the intra-operational production and parametric data which populate the forms and records which were attached to the production unit. The data may be collected from the factory floor either manually or automatically from equipment in an up-to-the-minute time frame.
6. **Labor Management**
   Provides status of personnel in and up-to-the-minute time frame. Includes time and attendance reporting, certification tracking, as well as the ability to track indirect activities such as material preparation or tool room work as a basis for activity based costing. It may interact with resource allocation to determine optimal assignments.
7. **Quality Management**
   Provides real time analysis of measurements collected from manufacturing to assure proper product quality control and to identify problems requiring attention. It may recommend action to correct the problem, including correlating the symptom, actions and results to determine the cause. May include SPC/SQC tracking and management of off-line inspection operations and analysis in laboratory information management system (LIMS) could also be included.
8. **Process Management**
   Monitors production and either automatically corrects or provides decision support to operators for correcting and improving in-process activities. These activities may be intra-operational and focus specifically on machines or equipment being monitored and controlled as well as inter-operational, which is tracking the process from one operation to the next. It may include alarm management to make sure factory person(s) are aware of process changes which are outside acceptable tolerances. It provides interfaces between intelligent equipment and MES possible through Data Collection/Acquisition.
9. **Maintenance Management**
   Tracks and directs the activities to maintain the equipment and tools to insure their availability for manufacturing and insure scheduling for periodic or preventive maintenance as well as the

Figure 3.3: MRPII to MES Data Flow Possibilities



response (alarms) to immediate problems. It maintains a history of past events or problems to aide in diagnosing problems.

10. **Product Tracking and Genealogy**
    Provides the visibility to where work is at all times and its disposition. Status information may include who is working on it; components materials by supplier, lot, serial number, current production conditions, and any alarms, rework, or other exceptions related to the product. The on-line tracking function creates a historical record, as well. This record allows traceability of components and usage of each end product.
11. **Performance Analysis**
    Provides up-to-the-minute reporting of actual manufacturing operations results along with the comparison to past history and expected business result. Performance results include such measurements as resource utilization, resource availability, product unit cycle time, conformance to schedule and performance to standards. May include SPC/SQL. Draws on information gathered from different functions that measure operating parameters. These results may be prepared as a report or presented online as current evaluation of performance.

3.4 INDUSTRY 4.0 AND THE EUROPEAN INDUSTRIAL STRUCTURE (EIS)

European Industrial Structure is fragmented – each production stage is realised by different plants/firms, located in different geographical areas – and geographically dispersed.

At the same time, it is characterised by just-in-time production, meant to avoid overproduction, waiting and excess investments. To do so, the whole production chain – from suppliers of raw materials to final assembly – must be strongly coordinated and synchronized. This means coordinating a complex network of suppliers segmented in hierarchically ordered tiers and under the authority of the company at the head of the chain. A prime example of these integrated and dispersed chains is the automotive sector: a car consists of about 15.000 parts and components, which are produced all over the EU. The implementation of production processes is strictly determined, just-in-time, by the development market demand.

Industry 4.0 precisely provides technologies which allow facing the challenge of coordinating and synchronising the actors of production chains which are fragmented and geographically dispersed. Of course, this produces strong consequences on labour.

The authority of the company at the head of the chain over its suppliers includes the definition of output planning, pace and speed of production, and labour organization. This creates a very high degree of integration within the network, to the extent that the boundaries between different companies become blurred, and new corporate-governance models emerge. Integration also implies homogeneity between the internal organisation and supply relations.

The development of demand determines production programmes, with a direct influence on the modulation of workloads in every single plant in charge of each production stage, irrespectively of whether they are external suppliers or departments of the same company. Moreover, to face fluctuations of any kind within the effective flow of materials inside production processes, a mechanism of feedback does exist: this mechanism connects each event with upstream operations [Gaddi and Garbellini, 2017b].

Computer-based systems such as ERP and MES, therefore, are crucial for vertical and horizontal integration.

For vertical integration, great importance is attributed to connections between plants belonging to the same Group but located in different places, or even different countries, and the connection with suppliers, which can themselves be located abroad. It follows that companies need to implement centralised software systems allowing to reach this goal, to strictly coordinate the various stages of the production process.

APS (Advanced Planning and Scheduling) is a software tool enabling the management of department resources, i.e. short-medium run planning of plants' productive capacity by order book.

MRP – a software for warehouse management – can detect and notify all inputs required to meet a specific order, which can be produced internally or purchased from external suppliers.

ERP (normally provided by SAP) is the tool for the overall production process management; as such, it is also used for supply orders management. The latter are often managed to impose a kanban logic even to external suppliers, which confirms the high degree of integration of production chains. In many companies, it is possible to deliver orders to suppliers by simply pressing a button in the logistics office. This is, of course, made possible by the fact that both customers and suppliers share the same computer-based management system.

Huge companies, moreover, develop specific purchasing strategies which strongly affect suppliers. An example is given by decalogue defined by CNH Industrial for its suppliers: open orders; the possibility of last-minute changes of supplies; suppliers must communicate their working times (vacations, closures, shifts, etc.); and so on.

When production is just-in-sequence – i.e., parts and components must be supplied in a specific sequence defined according to the customer production plans and cycle – integration is even closer. The model of supply plans management, in this case, is called Junjo (sequential calls); Kanban cards are collected daily and then electronically delivered to suppliers. This organisational architecture is managed with informatics systems to share information with suppliers, track daily/weekly orders and delivery schedules, etc.

Managing complex supply chains often requires resorting to informatics portals to record the complete list of suppliers.

SAP (ERP) is used to record all incoming orders, their location in warehouses, their destination and their utilisation; in other words, to track the lifecycle of each supplied part and component.

When a company receives an order from a customer, it is acquired through SAP; MRP verifies availability of parts and components and notifies the list of components to be ordered. Orders can be delivered to other plants of the same group or to external suppliers. In both cases, an electronic connection exists making it possible to implement the Kanban model.

Traceability of components within the plant and their handling is made possible by optical readers which record their location and utilisation.

The SAP is also used to integrate design activities performed by different plants of the group and in collaboration with external contractors. In this case, SAP works as an archive for design files developed with CAD. Design activities take place in the various plants of the same group at the same time and can be monitored in real time.

ERP and MES are also used to realise vertical integration.

In general, information systems inside the plants are based on ERP (SAP), which collects all data. It records parts, components and materials entering the plant as well as final product. In this way, SAP allows to manage and record all activities, from launching production orders to filing complete productions, as well as to record problems encountered, downtimes, etc.

In some plants, there is a software for machine-to-machine (M2M) connection in the entire plant; the system is connected to a server that collects all information and manages production processes.

MES delivers work-orders to production lines on a daily basis. It monitors the process of production, identifying the current stage and specific operation in progress and immediately detecting any problem; moreover, it tracks what every single worker does in every single moment (each worker, with an optical scanner or a touchscreen PC, reads a bar code which initialises the corresponding operation). Thanks to these systems, the Firms can trace the production process as a whole: from the inputs obtained by suppliers to the final product given to a customer.

Often the overall production flow is a sequence of scripts (orders, information) that are transmitted on a monitor (or PC) placed in the workplace. The infrastructure on which the flow is based is called 'Workstream', and works like MES; in this way, workers accomplish a double task: they move each specific batch from one machine to the other, and keep track of its manufacturing process. In this way it is always possible to know where each specific batch actually is; MES automatically processes each operation, follows them in real time and interact with the different machines.

3.5 WORK TIMES AND SCHEDULES

According to what emerges from the present research, changes of work times and scheduled were in general adverse to workers, with an intensification of the pace of work and a reduction of times for each operation. This modification was not due to the mere introduction of new technologies, but rather to the implementation of new business models, strictly determined by market conditions. Technologies supported these new business models, making a different organisation of labour possible by reducing operation times.

It is worth stressing an issue which is very relevant for Trade Unions: work times were not bargained, but rather unilaterally imposed by companies. The definition of work schedules was very different in the different companies considered in the present research – the production process of a welding machine is very different from that of a battery. However, since one of the tasks of Industry 4.0 projects in increasing productivity, in particular through a marked reduction times not only of the single tasks but of the overall production process, opening a discussion within Trade Unions aimed at bargaining work times is more relevant now than ever.

Reducing operation times is almost always a precondition for fully implementing organisational models such as lean production, just-in-time (or just-in-sequence) and WCM: production is carefully planned according to orders acquired, and deliveries must strictly comply with supply contracts. Synchronising all production stages is fundamental, and hence work times reduction is a key element of this strategy. Work times became in many cases extremely hard to be met by workers, due to the high degree of variability of workloads and production mix.

Order fulfilment times became more and more strict, binding and unpredictable, and strongly influences work times and schedules.

For this reason, a series of software tools acquired key relevance, in particular, software for:

- production planning (generally on a weekly basis);
- operations scheduling (on a daily, but also the shorter basis, i.e. in a matter of few hours);
- production orders delivery to the various departments, lines and workstations (with the aid of PCs, monitors, etc.);
- work orders rescheduling in real time;
- production process recording;
- recording concluded production stages, with the indication of the corresponding times and possible reasons for machine stoppages.

As stressed before, in the great majority of cases work schedules are unilaterally defined by companies. Manual operations are timed, analysed by Times and Methods departments, and translated into overall production and work orders planning. When operations involve machines, cycle times depend on machines themselves, and workers have to go after them. In fact, machines embed production scripts which in their turn precisely define work times, and hence workers are bound to act as mere appendices. Times recording does not concern single tasks only, but the whole production cycle (from orders acquisition to deliveries): rigorous time-keeping is, therefore, a precondition for coordinating the different production stages.

Catchphrases such as ‘transparent factory’ or ‘brilliant factory’ come from here: companies need to monitor the progress of every single stage in real time, in every single workstation, to rigorously keep times contracted with customers.

ERP and MES work as tracking and monitoring tools, by recording in real the progress of each stage and the production cycle as a whole; this, of course, implies monitoring what every single worker is doing in every moment.

Cycle times are embedded in barcodes attached to work orders and depend on the time necessary for machines to perform each task. Workers are particularly sensitive to time constraints imposed by machines, and this fact emerged several times during interviews.

Work times intensification is due to at least three reasons. First of all, tasks performed by workers are often complementary to those performed by machines, especially regarding loading and unloading. Secondly, under the guise of automating hard tasks – which according to companies should reduce workloads – workers are now in charge of operating more than one machine at the same time, while in former times each worker used to operate one single machine. Thirdly, workers are in charge of a series of tasks – self-checks, quality control, bureaucracy, i.e. compiling production sheets etc. - formerly up to someone else. All these tasks are normally performed with the aid of devices such as tablets, on-board PCs, etc.; data are immediately uploaded to company informative systems through ERP or MES.

3.6 WORK CONTROLS

The intensification of workloads was made possible by technologies which can track the start and end of every single operation. Companies often present this system as aiming at products traceability, but it is strikingly clear that they can also be used to control workers in real time.

Data concerning operation times are recorded, collected and monitored thanks to computer-based systems. Moreover, companies introduced devices for remote control of plants and equipment and, therefore, of the corresponding working performance. The key element is the possibility of real-time monitoring.

In many cases, people in charge of the department are provided with devices for remotely operate and control machines; software is also, in this case, ERP or MES, which collect all available data.

In general, procedures for performance recording and traceability imply the usage of barcodes and optical readers, connected to ERP/MES. Normally, the system matches codes associated with the worker, to the machine she operates, to the specific batch which is being produced, and to the specific component under process. All ‘openings’ and ‘closures’ are electronically recorded.

Real-time control of workers’ performance becomes, in this way, fully possible.

Machines also generate data acquired by the informative systems: about production volumes, quality, reasons for downtimes (breakdowns, set-up, controls, lack of materials, tooling, etc.) with corresponding times. All data are then used to produce detailed reports.

To conclude, it is hard to maintain that these control and monitoring systems are exclusively used for quality and efficiency controls, without monitoring the performance of single workers. Even in the cases in which this is actually the main task, it is impossible to disentangle the two kinds of control. Moreover, this also translates into the fact that, in the presence of problems or mistakes, the company can immediately trace back the identity of the single worker responsible for that. This does not happen at the level of every single plant: control can be extended to all plants of the group, even when located abroad.

Even more strikingly, this monitoring system often involves suppliers – who can remotely connect to machines for remote maintenance – and customers – who can monitor in real time the process of testing.

Moreover, workers' control is not limited to the lines, but also to clerical work.

Companies, in this way, can achieve an additional goal: computing production costs, the cost of every single worker, and hence decide whether to externalise or not some specific production stages, possibly to low-cost countries.

3.7 LEAN PRODUCTION

It is interesting to stress that many companies which are introducing Industry 4.0 technologies are already implementing lean production. In many cases, lean production and Industry 4.0 are strictly correlated.

We need only think of the implications the 5S pillars: the selection of tools and components to be provided to the various workstations, in order to keep only essential ones (S1, *Seiri*) means minimising wastes of time; the organisation and cleanup of workstations smooths worflows (S2: *Seiton*); the continuous inspection of machines and tools aims at avoiding breakdowns and stoppages (S3, *Seison*); defining standards (S4, *Seiketsu*) and keeping them (S5, *Shitsuke*) imply the continuous monitoring of workers' performance and of results achievement.

All these principles, which characterise lean production, are also on the basis of Industry 4.0.

The same reasoning can be extended to other characteristics of lean production: SMED (Single Minute Exchange of Die) aims at organising the production process in such a way as to make the switch between one stage and the following one smoother (*Mura*); *Takt Time* provides for the maximum time span allowed for completing each stage in compliance with demand, and hence sets the pace of work of all lines and at each workstation; the elimination of wastes (*Muda, Mura, Muri*) makes the whole system more stable, making it as smooth as possible, stabilising the pace of work and achieving standard conditions; the Workcell approach aims at getting final products at the lowest possible cost rather that keeping the cost of each single stage down, by reducing logistic costs thanks to the more efficient machineries layout and organisation; finally, just-in-time implies producing only products already sold, which in turn implies a different management of warehouses and commodity flows, having flexible and multi-tasking employees, a careful planning of working hours, and a close connection with suppliers.

This is exactly what Industry 4.0 technologies allow to do: among problems to be fixed, we find possible human mistakes, to be eliminated through the *Poka-Yoke* system, thanks to detailed instructions provided at each workstation or to automatic codes associations (batch-machine-component). Since MES can communicate with each device connected to a company's informative system, it can guide workers when carrying out the different operations, indicating the right components to process and the right sequence of operations to perform.

The integration between lean production and Industry 4.0 is very strong within logistic activities as well: supplies lines are automatically supplied by electronic kanban which are delivered both to warehouses and to external suppliers, which in their turn also make use of the same software tools and informative systems to track their supplies.

WCM, in the same way as Lean Production, is based on the concept of continuous improvement, and implies value added maximisation through the elimination of wastes and the involvement of all employees, at any level. Like Lean Production, it is based on three key concepts:

1. Value added: everything which is valued by customers;
2. Loss: any cost which is not associated with value creation;
3. Waste: loss is taking place in the presence of the use of more resources than what is strictly necessary.

Among the ten pillars of WCM, we can mention: Cost deployment (cost reduction evaluation, planning and monitoring); Focused improvement (elimination of main losses by eliminating process inefficiencies); Autonomous activities (including Autonomous Maintenance and Work Place Organization); Professional Maintenance (to void machines and equipments breakdowns); Quality Control (QC, to prevent manufacturing flaws and implement an ex ante rather than ex post control system); Logistic/Customer Service (to manage the internal flow of the production process, fine-tuning it by getting external actors involved – logistic activities are therefore crucial); Early Equipment Management (to speed up the implementation of new productions). Also in this case, a close relation between WCM pillars and Industry 4.0 technologies is apparent.

For instance, some companies an application of WCM exists which, from the point of view of technical KPIs, aims at strengthening the correct functioning of machinery concerning total working time – comparison between loading time (total time) and operating time (operating time).

Operating time depends on breakdowns, set-ups, adjustments, changes and starters. Net operating time, on the contrary, depends on stoppages and on functioning speed. Finally, value operating time depends on flaws and reworks.

Working on the improvement of all these issues should improve equipment utilisation, their performance, and the quality of final products. These three goals, together, determine overall plants efficiency.

However, reaching these goals have strong consequences on workers: the control of performance, the intensification of working times, and the introduction of performance-related premia.

3.8 THE MAN-MACHINE RELATIONSHIP

It is clear that Industry 4.0 technologies fit in the organisational background of lean production, and in a technological context marked by the advent of Flexible Manufacturing Systems (FMSs) . The book Flexible Manufacturing System [Shivanand et al., 2006] provides two alternative definitions of FMSs.

First, “[a] flexible manufacturing system (FMS) is an arrangement of machines [...] interconnected by a transport system. The transporter carries work to the machines on pallets or other interface units so that work-machine registration is accurate, rapid and automatic. A central computer controls both machines and transport system”. Or an “FMS consists of a group of processing workstations interconnected using an automated material handling and storage system and controlled by integrated computer control system.”

Moreover, “FMS is called flexible due to the reason that it is capable of processing a variety of different part styles simultaneously at the workstation and quantities of production can be adjusted in response to changing demand patterns.” [Shivanand et al., 2006, p. 2]

The basic components of FMS are:

1. *Workstations*: In present-day application, these workstations are typically computer numerical control (CNC) machine tools that perform a machining operation on families of parts. Flexible manufacturing systems are being designed with other types of processing equipment including inspection stations, assembly works and sheet metal presses. The various workstations are: (i) Machining centers; (ii) Load and unload stations; (iii) Assembly workstations; (iv) Inspection stations; (v) Forging stations; (vi) Sheet metal processing, etc.
2. *Automated Material Handling and Storage system*: The various automated material handling systems are used to transport work parts and subassembly parts between the processing stations, sometimes incorporating storage into the function.
   The various functions of automated material handling and storage system are: (i) Random and independent movement of work parts between workstations; (ii) Handling of a variety of work part configurations; (iii) Temporary storage; (iv) Convenient access for loading and unloading of work parts; (v) Compatible with computer control.
3. *Computer Control System*: It is used to coordinate the activities of the processing stations and the material handling system in the FMS. The various functions of the computer control system are:
   Control of each workstation; (ii) Distribution of control instruction to workstation; (iii) Production control; (vi) Traffic control; (v) Shuttle control; (vi) Work handling system and monitoring; (vii) System performance monitoring and reporting.” [Shivanand et al., 2006, pp. 2-3]

The main objectives of FMS are:

1. *To improve operational control* (reduction in the number of uncontrollable variables; providing tools to recognize and react quickly to deviations in the manufacturing plan; reducing the dependence of human communication;
2. *To reduce direct labour* (removing operators from the machining site; eliminating dependence on highly skilled machines; providing a catalyst to introduce and support unattended or lightly attended machining operation);
3. *To improve short-run responsiveness* (engineering changes; processing changes; machining downtime or unavailability; cutting tool failure; late material delivery);

4. *To improve long-run accommodations through quicker and easier assimilation* (changing product volumes; new product additions and introductions; differentiation part mixes; increase machine utilization - eliminating machine setup, utilizing automated features to replace manual intervention and providing quick transfer devices to keep machines in the cutting cycle -; reduce inventors - reducing lot sizes; improving inventors turn-over; providing the planning tools for JIT manufacturing).

The main differences between FMC (Flexible Manufacturing Cell) and FMS approach are the following:

1. Cells lack the central computer with real-time routing, load balancing, and production scheduling logic. They are generally controlled by cell controllers or by their own independent but interfaced machine controllers.
2. An FMS will be almost invariably connected to the higher-level computer within the manufacturing operation. In many cases, it is tied directly to the corporate computing system, which may also be running the MRP system, the inventory control system, and sometimes the CAD system in design engineering.
3. Cells are typically tool capacity constrained. Both the total number of unique limits single and multi-machine cells and redundant cutting tools that occupy available tool pockets. This limits the part spectrum that could be run through a cell at a given time without stopping the equipment and manually exchanging tools to accommodate different workpieces.
4. An FMS with automated tool delivery and tool management can be automatically transfer, exchange and migrate tools through centralized computer control and software independent of equipment activity. With a cellular application, the cutting tool count must be minimized to offset the limited tool buffer storage of the machine. Parts must be closely scrutinized, and part prints sometimes changed to match the family tool range with the available tool pockets.

[Shivanand et al., 2006, p. 21]

Industria 4.0 fits in the context of FMS by updating it with respect to the previous model. The main innovation is represented by RAMI4.0 (Reference Architectural Model industry 4.0) architecture.

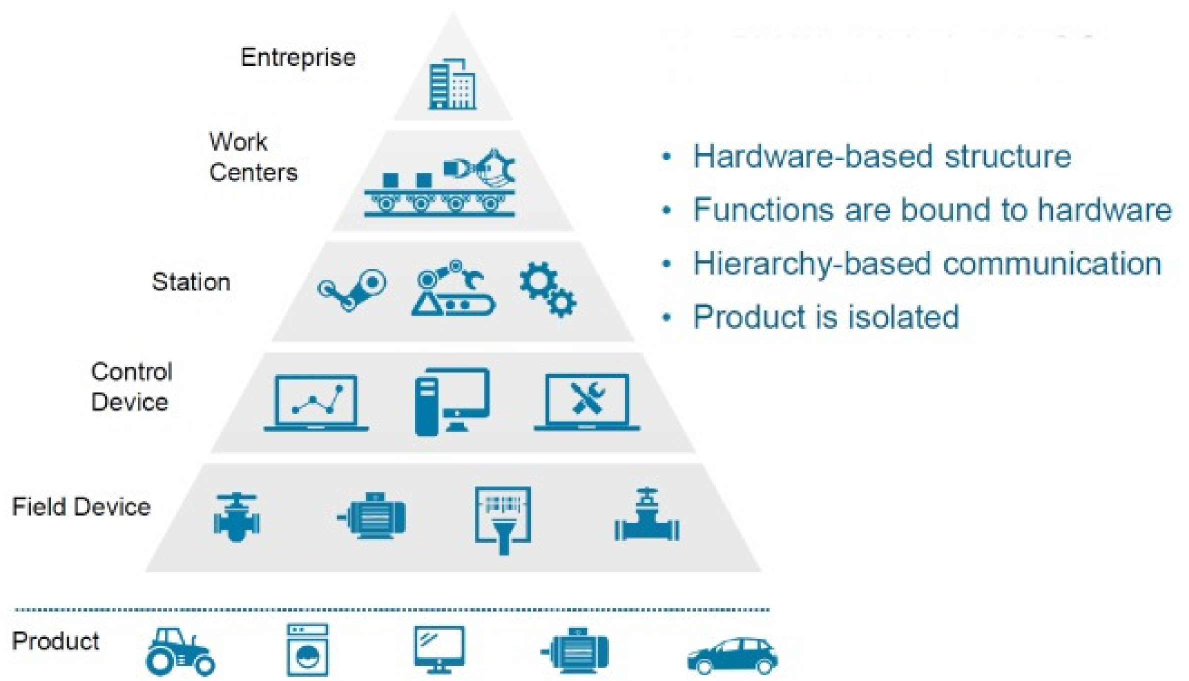
According to a publication by *Platform Industrie 4.0*, Industry 4.0: a) connects/merges production with information and communication technology; b) merges customer data with machine data; machines communicate with machines; c) components and machines autonomously manage production in a flexible, efficient and resource-saving manner.

The old factory is represented as in Figure 3.4.

First of all, from the hierarchical point of view, the new Factory 4.0 is characterised by flexible systems and machines and communication among all participants; functions are distributed throughout the networks; participants interact across hierarchy levels; the product is part of the network. This axe involves products, field devices, control devices, stations, work centres, entreprise, connected world.

Second: Architecture involves all layers: Asset (Physical things in real word: sensors, devices etc.); Integration (Transition from real to digital world; Interfaces between real world and IT representation); Communication (Acces to information: harmonized communication between the

Figure 3.4: The Old World: Industry 3.0



different layers and direct communication via real-time network); Information (Necessary data); Functional (Functions of asset;); Business (Organisation and Business Process).

Finally, the new Life-Cycle evolving from the old one (Development-Sale-After sale support) towards a model characterised by a direct link Development-Maintenance/Usage and Production-Maintenance/Usage.

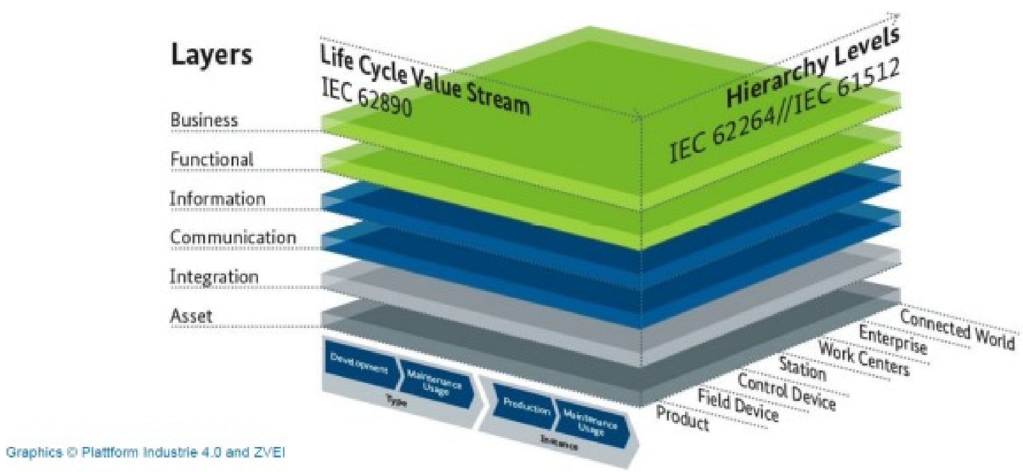
The three axis of this architecture model can be represented by Figure 3.5 described by Peter Adolphs (RAMI4.0, An architectural model for Industrie 4.0, 2015):

As already explained, FMSs also aim at reducing dependency on human communication. This is not something totally new: Dina [1982] used the expression *fase tecnologica* (technological stage) to say that the use of technology, besides boosting profits and upsetting the balance of power, aims at replacing human activity in the elaboration of an increasing amount of information; in particular, such replacement concerns direct man-machine and machine-machine communications. Dina described flexible production systems with a particular focus on the introduction, between the end of the 1970s and the beginning of 1980s, of ICTs.

A significant difference with respect to Detroit-type automation was that the latter did not imply dealing with information in real-time since the information was defined ex-ante, in the process of designing, and hence were embedded by machines as an inalterable mechanical memory. Even this kind of automation did not (or at least, was meant not to) leave room for the so-called informal organisation: not only the working cycle is rigidly determined by the structure of machines, but also controls were not available to workers.

In the 1980s, the technological stage was determined by capitalists to increase flexibility and

Figure 3.5: Industry 4.0 Architecture



regain control over labour; however, the seek for flexibility was limited by the impossibility of efficient control – which is now possible with Industry 4.0.

The term 'flexible automation' was coined to describe the ability of equipment to process more than one kind of product, to change the production mix easily and quickly, to implement makeovers easily, to introduce new models. Moreover, the term was intended to stress the higher degree of adaptability to destination markets – made possible by the fact that this was possible simply by reprogramming production lines, rather than replacing them with new ones – and the ability of the productive system to resist disturbances.

Hence flexibility, equipment automation and productivity increase could have been made possible by real-time elaboration of process information – nowadays, we would say of market- and customer-related information.

Computer science provided the basis for the circulation of information, to support flexible production systems: machines and robots connected by a transmission system, under the guidance of a central computer which defines business strategies according to production requirements, single units workloads, etc. This system started to engage clerical workers as well: thanks to the centralised informative system, they started the process of automation (CAD, CAC, CAT) and were directly connected to CAMs.

The information referred to by Dina are described in various teaching materials prepared for FIOM (La fabbrica automatizzata e l'organizzazione del lavoro – Automated factory and labour organisation); they are information of the following kinds:

- geometrical: shape, size, etc. of the part to be produced;
- technological: how to operate machines (mandrel speed, etc.);
- sequential: (binary) sequences of the various stages of the cycle.

In the 1980s, automation started to bring about the real-time automatic elaboration of most of the information concerning the production process, which allowed to avoid human intervention.

In the 1950s and 1960s, production lines stored information, but they could only be read, not modified – because, as stated before, such information was uploaded to machines in the stage of their production. Hence, variants were not possible. It was only with the following wave of automation that flexibility was added: the system can produce different elements at the same time, can implement production modifications without structural modifications of equipment, can face failures without complete shutdown of the production process. This was made possible by the ability to deal with information in a different way: not only automatically, but also with the possibility of modifying them. In particular, it was made possible by scripts uploaded to machines, stored in their memories and ready to be launched, and subject to be re-programmed whenever necessary through a keyboard. This wave of automation opened the possibility of interaction with machines control units; and interaction which, however, was not available to workers operating them.

Within FMSs, it is the central computers systems which stores, sorts and delivers working programs to the different workstations; which takes screenshots of the system status; which coordinates the various units and manages materials handling; which exchanges messages with terminals; and which receives, elaborates and updates data for maintenance and end-of-shift summaries.

ICT investments made in the 1980s concerned the flow of information about the production process: not only for storing data but also for real-time operational information management. The goal was that of reaching the higher possible degree of flexibility, at the same time keeping full, real-time control over the production process: this goal is fully reached thanks to Industry 4.0 technologies. While the task of 1980s investments was that of a higher and higher degree of integration of ICT in the production process (beyond single machines), the goal of Industry 4.0 is that of pushing such (vertical) integration even further, to the whole production chain (horizontal integration).

CNC and PLC are suitable for communication with monitoring computers: they collect and elaborate information in real time, to automatically detect and diagnose failures; they exercise a continuous and centralised remote control over machines and workstations, making it possible to get reports about production, times, performance, stoppages, etc.

Which consequences will this new man-machine relationship produce on manufacture 4.0?

Also in this case, workers are totally excluded from the usage of software at the basis of machines, lines, plants, and equipment functioning. This exclusion also concerns all aspects related production process information:

- Their elaboration is of competence of planning and engineering departments. In some cases, this service is not even provided internally, but by the companies which supplied equipment which are in charge of software updates, maintenance, etc. If it is clear that programming requires computer science skills, it is also true that workers could well be involved in the discussion concerning software goals (machines' performance, modes of operation, times, etc.);
- After being programmed, scripts are not uploaded by the worker operating the machine, but directly by programmers. In some cases, this is done by programming/engineering departments which remotely upload scripts through intranet or internet networks;
- Once uploaded, scripts are not always launched by workers: in some cases, the choice of

scripts to be launched is competence of the head of the department or the production responsible; in other cases, scripts are automatically launched by optical readers thanks to barcodes associated to the production batch, which in its turn is associated to a specific script;

- The fact that workers are not aware of the working of the machine is a potential additional source of alienation: information, data, scripts by which the system works are totally unknown;
- The utilisation of more advanced tools and machines (connected devices, smart devices, etc.), therefore, does not imply higher level skills for workers; on the contrary, tasks might even result simpler and poorer;
- Machines equipment is neither part of the competences of workers operating them;
- Workers are therefore only in charge of supporting tasks (machines load, unload, monitoring, etc.). Workers are mere appendices of the machines they operate, which are programmed and equipped by others; quite often, they do not have any relationship with these figures;
- The introduction of programmable robots and machines does not always improve working conditions; on the contrary, most of the times, workers are much more constrained by machines than before;
- Programmability, connectivity, flexibility, and increased automation do not imply an improvement of working conditions either; on the contrary, companies can take advantage of machines' increased autonomy to push towards a higher degree of skill saturation with workers having to operate more than one machine at the same time.

Since working times and methods fully depend on machines, there is no human control on workers anymore; the person in charge of controlling workers can be challenged or criticised, can make mistakes, and workers can negotiate with her. Machines, on the contrary, are indisputable.

Strategical decisions concerning these aspects are not dictated by mere technological necessities, but the rather specific social decision, in front of which it is necessary to start an appropriate union activity.

3.9 THE ROLE OF COMPANY LEVEL BARGAINING

Trade Union industrial relations

The new business models which are establishing themselves in our country after the implementation of technological and organisational innovations, coupled with market pressures faced by companies by just-in-time production, may have strongly negative effects on Trade Unions' bargaining power. Looking at the case studies illustrated in the present study, it is apparent that the room for bargaining – as well as the set of matters subject to bargaining – is becoming tighter and tighter. On the contrary, companies' bargaining power and their control on workers' performance strengthened: think of work organisation and planning and the saturation of workloads.

Moreover, organisational changes make companies seek new skills. Companies should train workers to face the new tasks they are asked to perform, but this is not subject to discussion with workers representatives either.

The lack of a shared contractual arrangement, and the new legal provisions introduced by the

Parliament, considerably weakened the legal tools available to Trade Unions. With these choices, the Government and Confindustria are increasingly pushing towards company-level bargaining, so far as to establish a direct relationship between every single worker and the company itself, in so doing jeopardising Trade Unions' collective action.

In fact, this would ensure workers' passive consent to decisions taken unilaterally by employers and imposed to workers' themselves, eliminating Trade Unions' autonomy.

Company-level bargaining

The management of all companies interviewed was available to provide information (about planned investments, technological and organisational innovations to be introduced, etc.) to Trade Unions and RSUs. However, independently of this availability, it will be increasingly crucial to provide for specific rights to information to be followed by discussion.

This point is particularly relevant given the implementation, by many companies, of lean production models and the Toyota Production System, which should encourage workers' active participation through remarks, proposals, suggestions concerning production organisation and single production stages. Even when this actually happens, workers' contribution is often underestimated and under-recognised.

Company-level bargaining will fully unfold its potentialities in the presence of union democracy, workers and Trade Unions having the right to participate in new organisational models and the introduction of new technologies planning, and of the actual right to information and consultation.

Of course, given the analysis carried out above, effective company-level bargaining could not but be extended as much as possible to the whole supply chain, to allow for bargaining of working conditions.

In short, a company-level bargaining process aiming at facing the main issues connected to Industry 4.0 should include the following ones:

- employment effects;
- the pace of work and working times;
- working hours;
- systems for the control of working performance;
- consequences, regarding workers' health/safety, of new technologies, also from the psychological point of view (stress);
- new organisation of labour and production;
- skills and training;
- externalisations, procurements, etc.;
- tools for workers' participation;
- productivity and distribution of wealth generated.

CHAPTER 4

Recommendations

First of all, a Trade Union's strategy on industry 4.0, to our mind, to be effective *cannot restrain itself* to an adaptive scheme and a mere reactive strategy. It is clear from the case studies that there is not a predefined recipe, even less a technological one. Each chosen strategy is a selection of alternative sets of variables; each set of variables is stressing different priorities. One of the key variables concern the relations between capital and labour as to employment, skills, working conditions, level of personal autonomy, collective rights, etc.

To choose an adaptive and reactive strategy means that the alternative sets and the different priorities will be defined only by the management and the ownership. The other option forces the management and the property to make crystal-clear their objectives from the project phase and allows trade unions and employees' representatives to develop an autonomous point of view, and to struggle for co-designing, shaping the course of action. If this option is not available in the set of existing industrial relations, this should become the first demand to fight for.

This option is not a recommendation only at the company or plant level. Trade Unions should keep the Industry 4.0 projects or to be more precise the digitalisation strategy – whatever is the national wording of it – at their face value of a coming revolution. If this is a revolution, it is unacceptable to consider that its social consequences on the working class and society at large can be considered as a deterministic effect of technology, something similar to a natural event. These processes of decision cannot be part of the private realm of the capitalists, part of the managerial prerogatives and proprietary rights. The involvement of Trade unions at each different institutional and social level - macro, meso and micro - is a political and social issue at the national and European level.

In the second place, this process of innovation represents for many generations of employees *a cultural and professional break*. The cultural break also affects the very concept of what a production process is about; the professional gap is distributed unevenly in the different age classes. As to the latter, there are cases of people not willing or not able to cope with the last technologies – it also happened before with the computer-aided design (CAD) software – but still able to deliver very high-professional contributions. In these cases, Trade Unions should bargain specific solutions for these people.

Coming back to the cultural break, when these breaks occur people can experience some forms of disorientation. It is of crucial relevance for Trade Unions to develop a critical understanding of the process of transformation as a multidimensional process - political, social, cultural, etc. It means to mobilise all the cultural, social and scientific competencies on one side, and on the other side, to seize this opportunity to mobilise their rank-and-file to capture the actual working experiences of the working class. The combination of the available social knowledge and the working experiences, through forms of action-research, will provide Trade Unions with an autonomous point of view of the transformation process. The very process of unfolding this critical and shared reflection at each level of the Trade Union's organisation is a way to avoid any forms of disorientation and to start to set an agenda.

Thirdly the agenda-setting should start with the *employment* issue. Trade Unions should transcend the bipolar tendency between prophecies of doom and techno enthusiasm that serve only to paralyse people further. As Freddi [2017] states:

> In particular, a lot of attention is currently put on intelligent machines and more specifically on robots and on their (possible) ability to substitute for human labour. This technological advance is typically a process innovation that, as we have seen before, is proven to have a direct negative effect on employment, when studied at the micro or meso level. However, macro-level studies, although partially weak due to data unavailability and the complexity of the models, showed that there might be compensation mechanisms that could mitigate these effects. Moreover, there is no consensus among scholars on the future effective capacity of robots to fully substitute for human labour, as there some skills such as flexibility, judgement and common sense or the ability to identify the purposiveness of objects that so far showed to belong exclusively to human's skills. If robots have received a great deal of attention so far, the impact on employment of other types of emerging technological opportunities such for example 3D printing, Internet of Things, Augmented reality, Big data Analytics have not been studied yet. These new technologies offer opportunities not only for process innovation but also for significant product innovation that a large number of studies proved to have positive employment effects.
>
> The main risks are in the area of process innovation at a micro and meso levels; we mean as meso level also the networked system of firms such as the value chain and the new industrial ecosystems. Trade Unions, therefore should make specific and fine-tuned assessment of the different situations, rediscovering the relevance of the work organisation design, and at the same time develop a framework for action at the macro level – the EU countries and the EU as a whole. Re-skilling programs are part of these strategies as well as industrial strategies on innovation with a clear directionality and priorities. [Freddi, 2017]

In the fourth place, the problem of *skills and competencies* should be analysed as a dynamic problem. One of the most debated topics, for its obvious social consequences, is that of the degree of substitution, by "smart" devices, of different professions and/or activities. Quantitative forecasts, critically assessed in the forthcoming literature review, start from some hypothetical assumptions.

The first regards the greater or lesser ability to codify the occupational activity. The more, in fact, the knowledge required for that specific activity is tacit (Polanyi) the more difficult, if not impossible, to turn it into a routine and then into codes that can be automated in the sense of Zuboff.

The second assumption is that the progress in artificial intelligence and robotics open scenarios of substitution of human labour even in non-routine activities, ranging from the world of production to that of high finance.

The weak point of these forecasts – like those by Frey and Osborne [2013] – is their static nature. It assumes that there is a predefined stock of routine and non-routine activities; the latter too, are partially replaceable, as in the case of interactive robots.

In fact, in the case of innovations, including those arising from scientific and technological progress, companies have the opportunity to develop new skills in ways that have been described, in cognitive terms, by Zollo and Winter [1999, p. 7] as *dynamic capabilities*, that is: "a learned pattern of collective activity through which the organisation systematically generates and modifies its operational routines in pursuit of improved effectiveness."

Dynamic capabilities are not an individual mechanism in a strict sense even if it has been set off and conveyed by the people involved. This involves a specific organisational pattern which, in the first place, allows one to express oneself freely and, in the second place, to have time and place resources to allow this dialectical interchange: the possibility, in other words, to organise discussion groups, seminars, etc.

Knowledge in use in an organization is always socialized knowledge that arises from the interaction between the continuous and dynamic people involved:

> Hence, our inquiry into organisational learning must concern itself not with static entities called organisations, but with an active process of organising which is, at root, a cognitive enterprise. Individual members are continually engaged in attempting to know the organisation and to know themselves in the context of the organisation. At the same time, their continuing efforts to know and to test their knowledge represent the object of their inquiry. Organizing is reflexive inquiry. [**?**, pp. 16-17]

The problem is not qualifying the skills only as a fixed stock or to think that the adjustment is just a learning process school-type. There is a dynamic that begins from the re-elaborating of personal and professional expertise in the light of a process of change; the very process of change also must be explained and critically examined. In conclusion, Zollo and Winter [1999, p. 17] state that "[d]ynamic capabilities emerge from the co-evolution of tacit experience accumulation processes with explicit knowledge articulation and codification activities."

This requires organisations to be open to these dynamics, a situation today provided quite exceptional. It, in fact, does not depend on a situation institutionally defined, as in the case of Mitbestimmung, but from daily working practices.

fifthly, Trade Unions should develop a positive agenda with clear-cut demands on "how to shape innovation in ways supporting fair and affordable working conditions, and to strengthen their capacity for autonomous action and decentralised self-regulation" [Krzywdzinski et al., 2016, p. 22]. As Krzywdzinski et al. [2016, p. 23] state, "based on past experiences with automation processes, the degree of process stability produced under laboratory conditions is hardly achieved in practice."

In so doing these processes produce "a very high need for improvisation and creative problem-solving – in a complex as well as simple production processes." [Krzywdzinski et al., 2016, pp. 23-24]

Unfortunately, past experiences show us that, even when there are not the consequences envisaged by advocates of a dystopian future, a polarisation process will occur producing winners and losers. Krzywdzinski et al. [2016], after having recalled examples of de-skilling in the previous transformation of the work – the third industrial revolution – highlight the risks faced by workers with tasks of feeding the machines, those jobs in Germany are classified as "residual work", but also workers with high skills.

The progressive widening of capabilities in concentric circles depicts the capacity development in any career. When there is a discontinuity in his/her professional experience - such as the intervention of the automate processes – as Zuboff [1988, 2016] defined it – then there is the risk that the higher levels of professional capacity can become obsolete through the degradation of the skills to a pure routine. The routine can be formalised and morphed into an algorithm, regardless of the context, and then, finally, replaceable by the algorithm and therefore automatable. The informate process, the one Zuboff defined, is much more complex. It requires, in fact, that the context does not disappear. The computerised system must be able to adapt its performance to the context, as in the case of collaborative robots that use probabilistic models of interaction with the context. In this second case, therefore, the replacement of human labour occurs, when it occurs, in the proper sense of the expression, without having to "degrade" the competence to a routine.

There are *risks, indeed, as well as opportunities*. The most obvious opportunities are the possibility of more ergonomic and safer Workplaces. Robots can, in fact, solve many problems, even in the collaborative version, for example by loading the machines with heavy and uncomfortable parts, leaving the worker with any adjustment tasks and guide of the machines. Examples of this type have emerged in our first field research' upshots. But just where the risks are greater, there are also opportunities. Krzywdzinski et al. [2016], for example, point out the possibility that the manufacturing work can be re-evaluated.

While in our field-work research we found this kind of case in the assembly work offline, and in companies working in small batches, at the time we did not find cases for assembly line workers, in productions based on high volumes and short cycle times. Also because, as the authors claim, "[s]uch a development, however, would require a shift away from today's predominant philosophy of lean production – a philosophy whose global triumph was celebrated as another industrial revolution not so long ago, and which has resulted in a return to design principles of standardised and short – cycle work." [Krzywdzinski et al., 2016, p. 24]

The emergence of lean production thanks to the reversal of the balance of power between the capitalists and the workers, described above, is in fact also reflected in the design criteria.

Lastly, a point to be emphasised, in fact, is that among the stakes of the class struggle there is also the *design principles*; what we have called, in the position paper, the critique of scientific rationality of the methods for the design and description of the systems. The principles and design methods are therefore part of the political and social struggle to take advantage of the windows of the aforementioned opportunities. In this case, we should make a distinction between designing for the capabilities, that is, for the design of computer artefacts that avoid the deskilling of work, and designing for democracy at the workplace, that is, the change of power relations in the workplace in favour of the employees. It means acquiring collective control over the processes of technological change.

Not only the two design processes have to be distinguished, but they are in constant tension between them. The risk, in fact, is, on the one hand, that the orientation to the capabilities will result in corporate union practices that feed forms of polarisation/segmentation of workers.

On the other side, an approach focused on the conquest of all forms of control of power by the workers and their trade unions on employment and work organization process – a sort of a direct causal link between the production control by workers and the company's profitability – is risky in the process of change in which there are at the same time:

1. The transition of the form of the firm from a stand-alone company to a network of firms,
2. The real subsumption of labour to finance
3. A radical technological change.

The risk is that the power of control will be emptied out from within.

It happens, in fact, that the overall conditions of the employees of a specific company are determined by choices and governance mechanisms of the production network entirely external to that enterprise; indeed, the very existence of that specific firm may be at risk for purely financial reasons, beyond the effectiveness and efficiency of the production results. All this is the outcome of the financialisation of the companies. As part of the transition from managerial capitalism, which has characterised the whole phase until the crisis of the mid-seventies, the one based on today's financial managers, the so-called money managers.

Segmentation and fragmentation affect the companies' social structure, with the construction of different segments and poles of working positions, ranging from permanent working position to on-call working positions. It affects as well as the relations between companies, depending on their position in the value chain, and, eventually, the labour market as a whole, with the introduction of the "work on demand". This is a form of on-call work without the legal status of an employee, however precarious, and the creation of a large industrial reserve army of labour (Marx) which, according to some experts, could become a structural fact. Fragmentation went up to the explosion in individual and isolated forms of work without any protection and law and faked as free-lance positions.

Here, then, that the sort of a direct causal link model – between the production control by workers and the company's profitability – no longer works, except the handful of companies that control the main industrial sectors. It also works for the layer, of minority and highly specialised companies that need stable and highly skilled workers, in a very significative proportion, relative to their total workforce.

The process of setting up an alternative project, then, has to join the conquest of new forms of power control, adjusted to the new unit of analysis and action. The process should also deal with a capacity of intervention on the criteria themselves of technological and organisational design, which requires an idea of society and the role of work; this we meant when we used, in the position paper, the two requirements: "A critique of the political rationality of the design process" and implementation of these technologies, and "a critique of the scientific rationality of the methods for the design and description of the system."

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