Innovative Technologies and Employment

1. Introduction

In the general framework of the "Technology-Employment" Alliance, this Report is focused on trying to understand and highlight the impact that emerging "disruptive" technologies might have, in qualitative and quantitative terms, on the future of work, especially in the industrial and service sectors.

The findings of the Report have been achieved by analysing the international literature on these topics and consulting, through workshops and interviews, knowledgeable experts: scientists, technologists and managers of business firms. In this way it has been possible to gather different points of view and prospective evaluations of some of the most relevant players in the processes that relate technology innovation with employment.

The approach followed in this investigation avoids the use of quasi-deterministic methodologies, which form the basis of some of the most cited prospective analyses from think-tanks and entrepreneurial associations. The method assumes a straightforward relationship between innovative technologies, especially those in the area of ICTs, and the number and tasks of jobs and occupations.

On the other hand, we are fully aware of the structural complexity of the evolution of the labour market, especially in countries like Italy, Portugal and Spain, where many public policies have been designed to regulate the labour market, contrasting with the negative impacts of technology and organisational innovation, particularly those promoted by global players in the field of distribution and transportation.

2. Innovative Technologies

We are entering into the 4th Industrial Revolution, driven by some emerging disruptive technologies, such as:

- <u>in the ICT area</u>
  - Big Data

- Artificial Intelligence
- 4D printers
- Advanced robots (exoskeletons, bio-robots, humanoid robots)
- Block chain

- in the Biotechnologies area
  - Neurotechnologies
  - Epigenetics
  - CRISF Inclusion

- in the Nanotechnologies area
  - New materials used as Systems

- in the Energy/Environment Technologies area
  - New generation batteries (micro and nano)
  - Micro/Nano sensors
  - Mini/Nano satellites
  - Internet of energy
  - CO2 sequestration

Most of these families of technologies are pervasive and generate relevant impacts on the production processes and structures of many sectors in agriculture, industry and services. But the time horizon for these impacts to occur on a remarkable scale is quite different for each family, and ranges from the medium to the very long term.

For example, the development of advanced batteries that allow very effective and efficient storage of energy (with costs that are comparable and competitive with today's processes of energy production, which is a mandatory condition for the wide diffusion of renewable energy sources) may only come into being in the next 10 or even 20 years.
In fact, the effective solution of the problem of energy storage requires an approach that is very different from those followed so far, which should he based on the integration of many different disciplines.

On the other hand, many families of digital technologies have passed the stage of applied research and are likely to be industrialized in the short-medium term.

But what lowers the rate of diffusion of some digital technologies is the limited absorption capacity of potential users: there in a mismatch between the supply and demand of these technologies, which are under-exploited, so lowering the speed of development of new features.

A similar factor holds back and limits the full exploitation of the potential of new materials, built on the basis of interfaces and capable of substituting half of the existing materials. But the many options of the features and performances of new materials may mean that potential users are unable to precisely define the needs of the applications and, therefore, the type of materials required to meet those needs.

In any case, the development of all families of disruptive technologies requires the adoption of the Open Science approach, which through the Internet of Knowledge can lead to radical scientific results that can subsequently, through on Open Innovation approach, be transformed into economically feasible industrial achievements.

Research activities must be made more efficient by the use of Transitional methodologies, which start by setting the target performances of new products and processes, then identify the missing knowledge items and focus the research activities just on them.

3. Industry evolution

3.1 General features

Thanks to the innovative technologies previously outlined and, most of all, their interactions which amplify their impacts, we are entering the 4th Industrial Revolution at top speed.

The convergence of Biotechnologies and Nanotechnologies is generating a very new manufacturing paradigm: "from Micro to Macro", substituting the traditional one of "from Macro to Micro".

Innovative materials can be designed and manufactured with a large variety of advanced functions they can perform, in response to the many differentiated needs of users and, ultimately, of consumers.

Almost all industrial processes will be affected by this radical change of paradigm, requiring equipment and machinery that is very different from existing ones.

Moreover, advanced automation, largely based on AI, with a new generation of robots (anthropomorphic, bio-robots, exoskeletons, etc.), is not only going to radically change manufacturing activities but has the potential, at least where technical feasibility is concerned, to transform sectors like healthcare and finance, which involve a substantial share of knowledge-based work.

Even non-technological activities, like those of artists and humanists, are likely to be affected by the upcoming technological revolution.

But its consequences go far beyond the production processes and encompass the structure of firms, their business models and organization.

While in some industrial sectors, such as pharmaceuticals and automotive, manufacturing is going to be carried out by large firms due to the need of economies of scale in R&D and production, the "factory" as a system is shrinking not only as a central location, but also as a time-organizing institution.

A new production chain structure is emerging, shaped as a "constellation" of firms located all over the world. At its centre, the "star" carries out the most knowledge intensive activities, such as strategy elaboration, R&D, product and process design, marketing, while manufacturing is made in specialized plants dispersed over space on a global scale, where favourable economic and social conditions exist (access to raw materials and specialized components, low labour cost, less strict environmental regulations, proximity to the users/consumers, etc.), as well as time, allowing workers to calibrate their trade-offs more precisely.

Other models of manufacturing firms are being conceived and implemented by taking advantage of the new technologies, first of all the 3D and 4D printers, on the one hand, and the request of customized, emotionally intensive and differentiated products from consumers on the other.

So, many FabLabs are going to be installed in open environments, enhancing the implementation of the Cottage Industry model located in urban areas, where the demand for the products with the features listed above is high and there is relevant spending capacity.

People that manufacture at home will serve as "providers" that sell to others, primarily on the web. Individuals will see it as a low-risk, low-overhead business opportunity to manufacture from their basement, spare room, garage or dorm room. They will discover a niche market and serve this market from their home.

Today the ongoing model of Industry 4.0 can be considered a starting point of the evolution of industry, towards a structure that pursues the objective of sustainability and includes customers in the product and process design and implementation. The industry of the future is expected to be smart, sustainable and inclusive; technologies can make a very relevant contribution to achieving this goal, if supported and accompanied by many other factors in the areas of economy, policies, society.

Another relevant factor shaping the industry of the future is the spread of the Shaping Economy model, which is going to generate large and deep impacts on some sectors of manufacturing, first of all the automotive field.

3.2 The role of AI

One of the main driving forces of the 4th Industrial Revolution is Artificial Intelligence, which together with other ICTs, leads to highly digitalized intelligent production processes and structures.

All sectors will be affected by the use of AI; some examples are reported below and are taken from the Innovation Trend Report: "Artificial Intelligence Revolution" by the Intesa Sanpaolo Innovation Center.

Agriculture

The main impact of Artificial Intelligence on agriculture will be through the widespread adoption of autonomous machines, simply called robots, both aerial and ground-based.

Self-driving drones can be employed for specific tasks, like pesticide spraying, as well as surveillance and real time data collection. Ground-moving machines range from autonomous planters to harvesting robots, up to and including driverless tractors equipped with sensors, radar and GPS.

The other side of AI's application in agriculture is represented by intelligent "systems": intelligent irrigation, where water distribution is based on multiple parameters monitored in real time and on weather forecasting; vegetables selection, using technologies like image recognition to identify and discard vegetables affected by diseases; herd monitoring, with face recognition systems trained on cows and other mammals, that are able to monitor body conditions and feeding; greenhouse climate controllers, that optimize the usage of light, heating and water using a biological model of plant growth based on environmental parameters.

Thinking ahead to 2050, when the world population is forecast to be around 10 billion, a new "revolution" is needed in agriculture to produce more of a higher quality and in a sustainable matter. It will make use of advanced biotechnologies, robots, sensors and 3D printing.

Deep Learning is, for example, capable of the monitoring and recognition of new crop disease on a worldwide scale; biologists and epidemiologists are working with this technology to create a system that will be able to recognize not only currently known crop diseases, more than two dozen, but also the unknown ones, based on the image analysis of all photos taken and uploaded to the central system by all the farmers around the globe.

Big savings and reduction in ground pollution can be obtained exploiting computer vision techniques and intelligent sprayers that in a fraction of second are able to analyse the condition of each plant and distribute the pesticide only if and where it is needed.

Automotive

Autonomous driving cars are no longer a surprise to anyone.

They are one of the first and maybe the most well-known real world applications of Artificial Intelligence technology.

What isn't so clear to most of us is that such a revolution will totally change not only our way of commuting, but also the landscape of our cities.

Once a car is able to autonomously drive, there is no difference in whether it does that with or without people onboard. This means that, after having completed the main task of transporting people to work, or to home, the car can go and park by itself, or do its maintenance or refuelling. The car parks of the future will not have any infrastructure for humans, elevators, lighting, stairs, restrooms, safety systems, thus requiring much less space and providing maintenance or recharging services.

Car manufactures have to be aware that the business model itself is going to change.

They will sell fewer products, cars and spare parts, and it will convert to a service based model, where the user pays on a consumption base. The “rented” vehicles could be used according to an exclusive or shared model, with a real-time optimization of routes based on interconnection with other running vehicles and environmental conditions.

While today car navigation systems are working on being able to know traffic conditions in real time and taking alternative routes, predictive software will enable us to forecast the traffic situation half an hour before it happens, making a significant contribution to eliminating traffic jams from our cities.

The internal space of future cars will provide a range of new services, from entertainment to health care and office facilities.

The cars will be an “erratic server farm” with very high computing power, and for this reason companies like Toyota are making huge investments in partnership with MIT and AI start-ups, to play a leading role also as a software manufacturer.

Financial services

The financial environment is one of the most impacted by the pervasive use of Artificial Intelligence.

There is on-going disruption in the banking industry, which is shifting from the real world to the online one at a continuously increasing speed, and this is true not only for the customer-facing use of the service, but also the decision-making processes taking place in the back-office.

In the field of cybersecurity, Artificial Intelligence is needed to provide the machines with the ability to detect unknown attacks and to react to them without even the intervention of human supervision. Deep Learning and Predictive Analytics will let the computers identify almost in real time new behavioural patterns that can be a signal of new type of cyberattack.

Robot Advisers will help, or even substitute, customers’ relationship manager in matters of investment decision.

Healthcare

Many signals around the world show that the healthcare sector is going to be the lead industrial area where Artificial Intelligence performs a true revolution.

In healthcare there has been immense development in collecting useful data from personal monitoring devices and mobile apps, from electronic health records in clinical settings and, to a lesser extent, surgical robots designed to assist with medical procedures and service robots supporting hospital operations.

In similar way to what we are getting used to in financial services, a new generation of Digital Assistants, in this case Digital Nurses, is ready to assist the patients at their home, giving immediate feedback on care decisions and reducing the intervention of doctors to only when it is really needed.

Artificial Intelligence technologies will also be embedded in portable personal devices and, when the hardware has been “squeezed” enough, we’ll find them in devices like smartphones and similar.

Manufacturing

The rapid deployment of advanced Artificial Intelligence technologies in manufacturing processes is one of the main reasons for the on-going reshoring process.

The cost of manual labour is no longer a critical production factor, whereas flexibility and reaction speed are.

The increasing demand for highly customized products, together with a shorter and shorter timeframe required between the design phase and the delivery one, is incompatible with a model based on high production volumes and long transportation times.

In this scenario, AI is a key success factor because it enables real-time problem detection and prevention, production rescheduling and replanning, make-to-order management and delivery times that are days or even hours.

Moreover all these technologies are available in a “per-service model”, with an operational cost that is just a fraction of the cost of a traditional ERP, and this opens up such technology to small and medium enterprises too.

Why should a dealer keep a warehouse filled with spare parts? Image Recognition can analyse the buyer’s need while at his/her home and design a replacement part that perfectly fits the long used car or appliance, the AI based order management system searches for which suppliers have, exactly at that moment, the necessary raw materials at the best cost, sends an autonomous drone to pick up the supply, delivers it to the dealer’s 3D printer, and then flies it to the customer’s address with the final product.

Regarding the coexistence of robots and humans in the same working environment, it is important to note that it is considered so strategic that ISO has published technical guidance to deploying a safe robotic system to operate side-by-side with human workers.

ISO/TS 15066 is defined as “a game changer for the industry. It will reassure and guide both robot system developers and users, encouraging investment, development and application of this technology.”

4. The new Technology-Employment relationship

It is widely expected that the new disruptive technologies will transform almost all production processes and structures and are going to deeply change jobs, in terms of numbers and professional capabilities.

An overall view of the expected impacts of emerging industrial ICT technologies by 2025 is provided by the following list:

Emerging industrial technologies, global, 2015-2025

- **Wireless sensor networks**, using smart sensors and micro-electromechanical systems, will continually monitor environmental factors, such as temperature, pressure, and vibration
- **Collaborative robots** will work side-by-side with humans on the manufacturing floor, performing tasks that are unsafe or require a high degree of precision.
- **Femtosecond and picosecond lasers** will uses ultra-fast pulses for precision machining, without overheating processed surfaces.
- **Haptic interfaces** will provide the sense of touch in remote-controlled operations.
- **3D** will allow for quick, cost-efficient, small-batch manufacturing.
- **Automated safety systems** will continually monitor the factory floor, moving workers away from unsafe conditions in real time.
- **AR** delivered through head-mounted displays will provide real-time information about the factory floor.
- **VR** will help train workers by simulating events.
- **Machine vision** will allow automated machines and robots to analyse images for task performance or machining.
- **Intelligent RFID** beacons will allow the seamless tracking of products throughout their lifecycles.
- **Manufacturing AR systems** will project AR interfaces throughout the factory, collecting data and decreasing errors.
- **AVGs** will autonomously transport materials on factory grounds during the production process.

This trend is quite apparent if we look at recent years: in many industries and countries the most in demand occupations or specialities did not exist 10 or even 5 years ago and the rate of change is likely to accelerate.

Technological, socio-economic, organizational, geopolitical and demographic factors and the interactions among them will generate new categories of jobs and occupations. There will be changes of the skills required in either old or new jobs in most industries as well as the place and time of working, leading to new management and regulatory challenges.

It is expected that many jobs and occupations will disappear, humans being replaced by machines in a wide range of work activities.

This process involves not only blue collar manufacturing workers, but also white collar workers, and even professionals.

According to the World Economic Forum, by the year 2020 an estimated 5 million jobs are predicted to be replaced by machines. Up to now most job replacements have been in manual labour or simple tasks, but over the next few years, these replacements will involve more intellectually intensive, traditionally “white collar” jobs.

Robots, 3D e 4D printers and other AI based machines will increasingly replace routine types of work, even the complex routines performed by artisans, factory workers, lawyers and accountants, office workers who do repetitive jobs such as writing reports or drawing up spread sheets are easily replaced by software. AI and Big Data technologies will improve performance by capitalizing on previously unidentified patterns and automated time consuming tasks, and providing a personalized adaptive and intuitive experience.

Demand will grow in the service sector for non-routine and creative intensive and well paid tasks, on the one hand, and many routine, low skilled and low paid tasks, on the other hand. It is doubtful whether the gains at the top of the labour market will offset the gains on the low terrible jobs at the bottom.

Regarding this balance, one has to take into consideration that in some high added-value service sectors, such as healthcare, environmental control, culture, there are many major possibilities of creating new occupations and jobs, eventually through start-ups, given the many still unsatisfied needs of better performing services.

At the opposite end of the scale, many occupations have grown in the low quality service sectors, with low salaries, mostly with unstable work contracts, that are taken by young people, connected to digital platforms (such as those of Amazon, Deliveroo for delivering goods).

It’s not clear what is going to happen in the medium term.

Many studies, analyses and forecasts have been carried out, but no reliable and shared conclusions have been reached.

For instance, a famous report by Michael Osborne of Oxford University, published in 2013, found that 47% of jobs in America were at high risk of being "substituted by computer capital" soon. More recently Bank of America Merrill Lynch predicted that by 2025 the "annual creative disruption impact" from AI could amount to 14-33 trillion, including a 9 trillion reduction in employment costs thanks to AI-enabled automation of knowledge work; cost reductions of $2 trillion in efficiency gains from the deployment of self-driving cars and drones.

The McKinsey Global Institute, a think-tank, says AI is contributing to a transformation of society "happening ten times faster and at 300 times the scale, or roughly 3,000 times the impact" of the Industrial Revolution.

The McKinsey study continues to analyse where the automation of that activity is technically feasible. In fact it assumes that:

- Predictable physical work is 78%: for example: welding and soldering on an assembly line, food preparation, or packaging objects.
- Unpredictable physical work is 25%: for example: construction, forestry, or raising outdoor animals.

Since predictable physical activities figure prominently in sectors such as manufacturing, food service and accommodation, and retailing, these are the most susceptible to automation based on technical considerations alone.

Automats, or automated cafeterias, for example, are a reality. Now restaurants are testing new, more sophisticated concepts, like self-service ordering or even robotic servers.

Retailing is another sector with a high technical potential for automation.

McKinsey estimates 53% of its activities are automatable. Packaging objects for shipping and stocking merchandise are among the most frequent physical activities in retailing, and they have a high technical potential for automation.

But all of that depends also on skills: many jobs can be automated, but some activities more than others.

What makes these forecasts rather unrealistic and unreliable is their basic assumption that the impact of new technologies on jobs and occupation can be anticipated by means of quasi-deterministic rules and models.

These models do not take into proper consideration the "institutionalized" feature of the labour market, at least in most European Countries, especially Italy, Portugal and Spain. The processes within this market are carried out in a framework of rules and constraints that are the output of the interactions among the different players, such as governments, firms and their associations, trade unions.

As Nobel Prize winner R. Solow states, the labour market is a "social institution" that for sure is heavily influenced by technology innovations, but is influenced by the interactions and conflicts among the previously listed players and by related public policies.

All of this poses some new problems of regulations and work contracts, as it is necessary to devise new methodologies for measuring the output of the work and giving it an appropriate and satisfactory economic reward.

In many cases of loss of jobs, especially in the manufacturing industry, due to automation and technology innovations in general, governments have been active in promoting agreements between firms and trade unions targeted at designing and implementing some tools that could lower the negative impact on workers. In many countries, firms are requested to elaborate "social plans" in order to find new occupations for the workers affected by technological change and deployment.

More than these institutional and regulatory factors affecting the dynamics and the structure of the labour market, one has to take into consideration the changes taking place in the organizational models of firms of any sector.

Many models fall under the heading of "Smart working" and are based on an extensive use of digital platforms, through which workers, operating in places different from the firm's offices and following a non-fixed and flexible time schedule, deliver their professional contribution to the firm's activities.

This model is a response to the growing need of workers, especially young "millennials", to work in a largely independent and autonomous way, giving relevant room to their personal interests and goals.

The complexity of the organizational approach to Smart Working has led in recent years to a variety of proposals for its definition, although none are fully identical, even if they show many similarities.

Some of the proposed definitions are listed below:

- Agile Working:

"Agile working is about bringing people, processes, connectivity and technology, time and place together to find the most appropriate and effective way of working to carry out a particular task. It is working within guidelines of the task, but without boundaries (of how you achieve it)" (Allsopp, 2010).

- Flexible Working:

"Flexible working arrangement (FWA) is a spectrum of work structures that alters the time and/or place that work gets done on a regular basis" (Workplace Flexibility, 2010).

- Smart Working:

"From the outset we had defined 'smarter working' as letting people work where and when as they wished as long as it delivered the right results, saved costs and respected the planet. Space, technology and people management worked together intensely to make the business more effective" (Clapperton & Vanhoutte, 2014).

"Smart Working is an approach to organizing work that aims at driving greater efficiency and effectiveness is achieving job outcomes through a combination of flexibility, autonomy and collaboration, in parallel with optimizing tools and working environments for employees" (Capgemini, 2007).

"The term Smarter Working describes a new, more enlightened work environment that literally breaks down the physical barriers of the office as we know it. More and more, workplaces are being thought fully optimized to help employees do their best work anywhere and anytime. While Smarter Working is certainly helping organizations to increase efficiency and to reduce costs, it's also enabling them to provide a workplace that better reflects how we work, and to fully leverage employees' dynamic creativity and emotional connection to work." (Plantronics, 2012)

Smart Working is an innovative approach to work organization which integrates and overcomes traditional concepts such as teleworker from home by critically considering all traditional factors (physical space, times, tools) with the aim of achieving more freedom and responsibility of workers (Politecnico di Milano)

By comparing these definitions one can draw some common features of the new work organizational standard, such as:

- Cooperation
- Flexibility of working conditions
- Reshaping of physical space
- Technology innovation
- Autonomy of decision making
- Responsibility

In order to implement Smart Working, some relevant innovations have to be developed in the organizational framework of a firm, regarding:

- Sense of community, through
    - Hierarchy
    - Functions
    - Family
    - Company wide
    - Open Network

- Empowerment, through
    - Command & Control
    - Flexibility vs Standards
    - Performance based evaluation
    - Collaborative good setting
    - Full empowerment

- Flexibility, through
    - Restrictive work
    - Flexible time
    - Flexible work
    - Work-life balance
    - Border free work

- Virtuality, as
    - Physical
    - Communicative
    - Collaborative
    - Mobile
    - Fully adaptive

The following figure describes the actions that suggested at management level in order to implement Smart Working

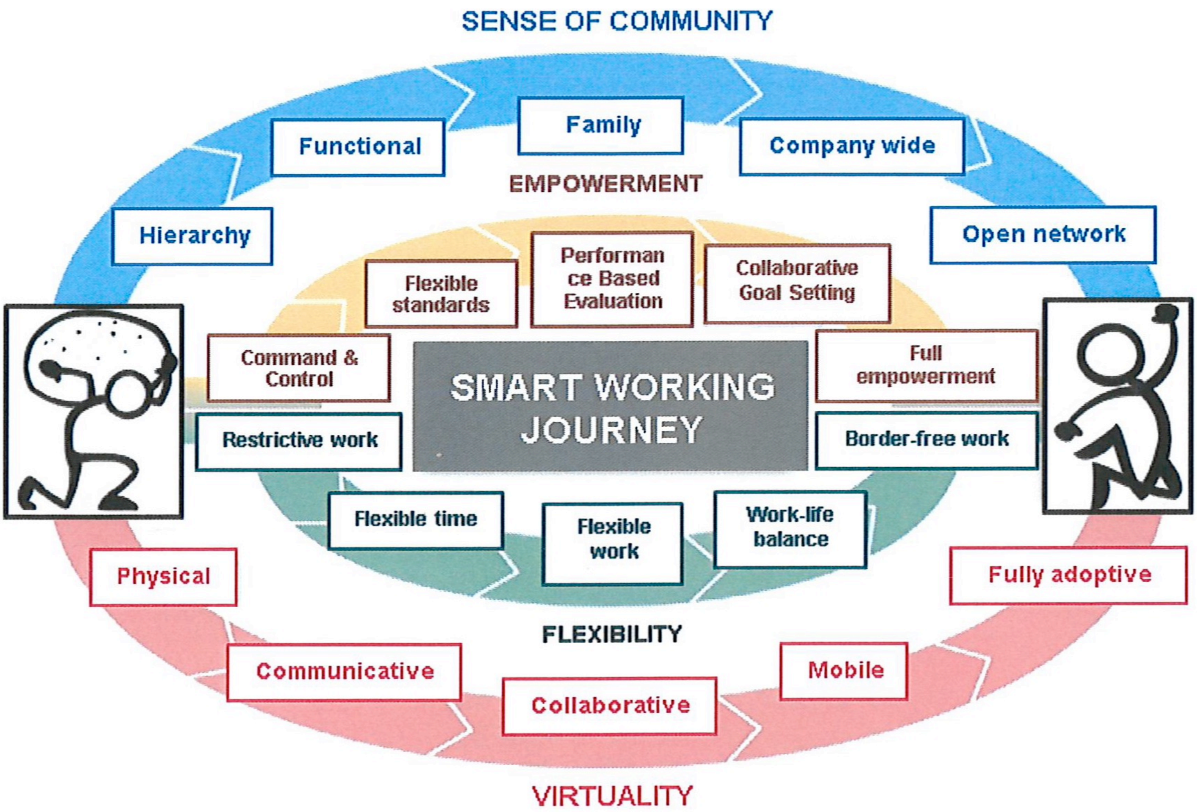


Figura 16 – Lo Smart Working Journey

Fonte: Osservatorio SW, 2013

Some models have been built with the aim of implementing Smart Working that maximize the business performance and workers' welfare.

Their use greatly depends of the characteristics of each organization.

One of the main obstacles to the implementation of the model of Smart Working is the existence of a well-structured and comprehensive set of definitions and regulations that do not take into account the flexibility of work delivery in time and in space.

Some suggestions can be proposed in order to promote the diffusion of Smart Working, such as:

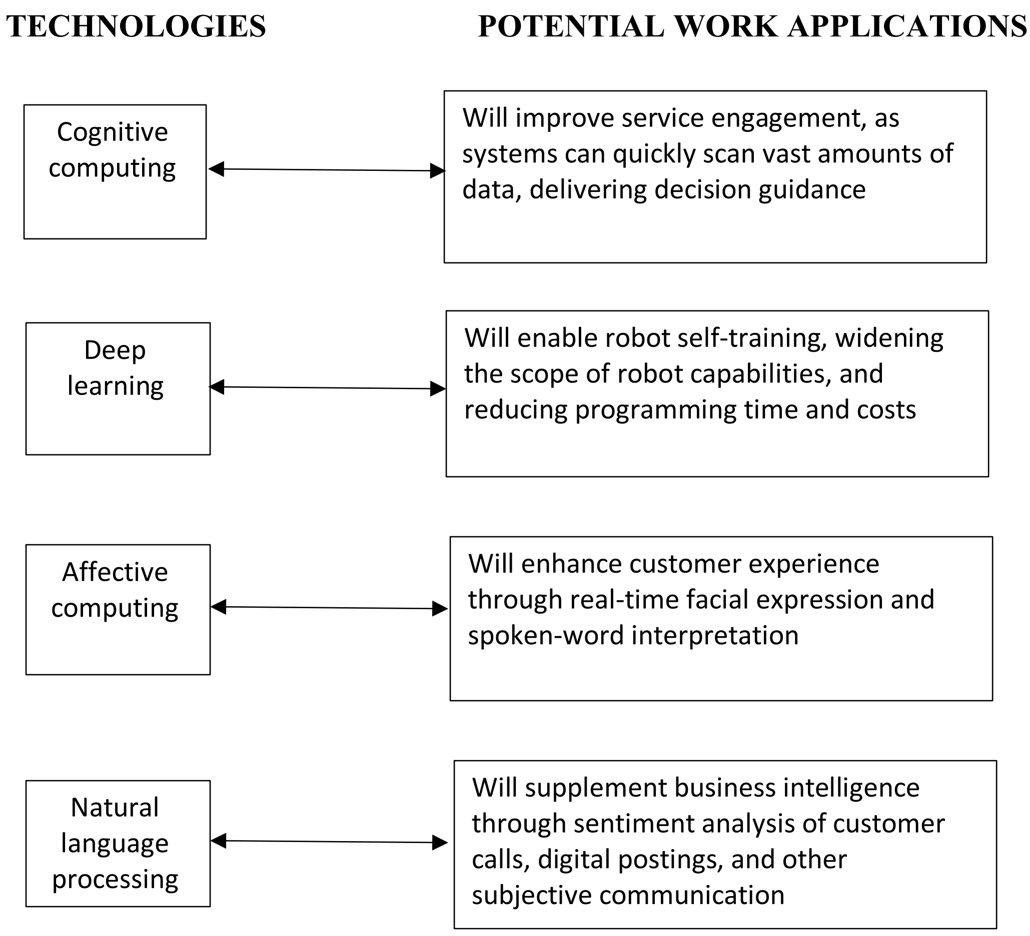
- to enlarge the notion of working space and to redefine safety and health policies;
- to revise the structure of work contracts and assume the use of new technologies (video, web, conference, Internet, social tools) that allow greater freedom in terms of space and time, more than conflicts with trade unions;
- to promote a deep change of the work culture and practise, basis of traditional reward systems, by giving workers freedom to manage their work and by designing some reliable methods to define and to measure work output.

These considerations are confirmed by the fact that some innovative technologies have different impacts on employment in different institutional and political frameworks.

In any case humans will have to be mentally prepared for the fact that some of our jobs will be lost to AI and automated systems.

By 2035, the global number of industrial robots in operational use could top 5 million. Current low robot density rates in many countries point to plenty of potential growth.

More than in manufacturing, robots are going to be largely used in the professional services sector, given the scope of potential applications and increasing advances in safety and cost of use, as shown in the following figure.



5. The new Skills

The world of work is changing faster and more drastically than at perhaps any other time in recent history. According to a research study from the World Economic Forum, 35% of the skills necessary to thrive in a job today will be different five years from now: transformation will require social and emotional skills such as creativity, initiative and adaptability to navigate.

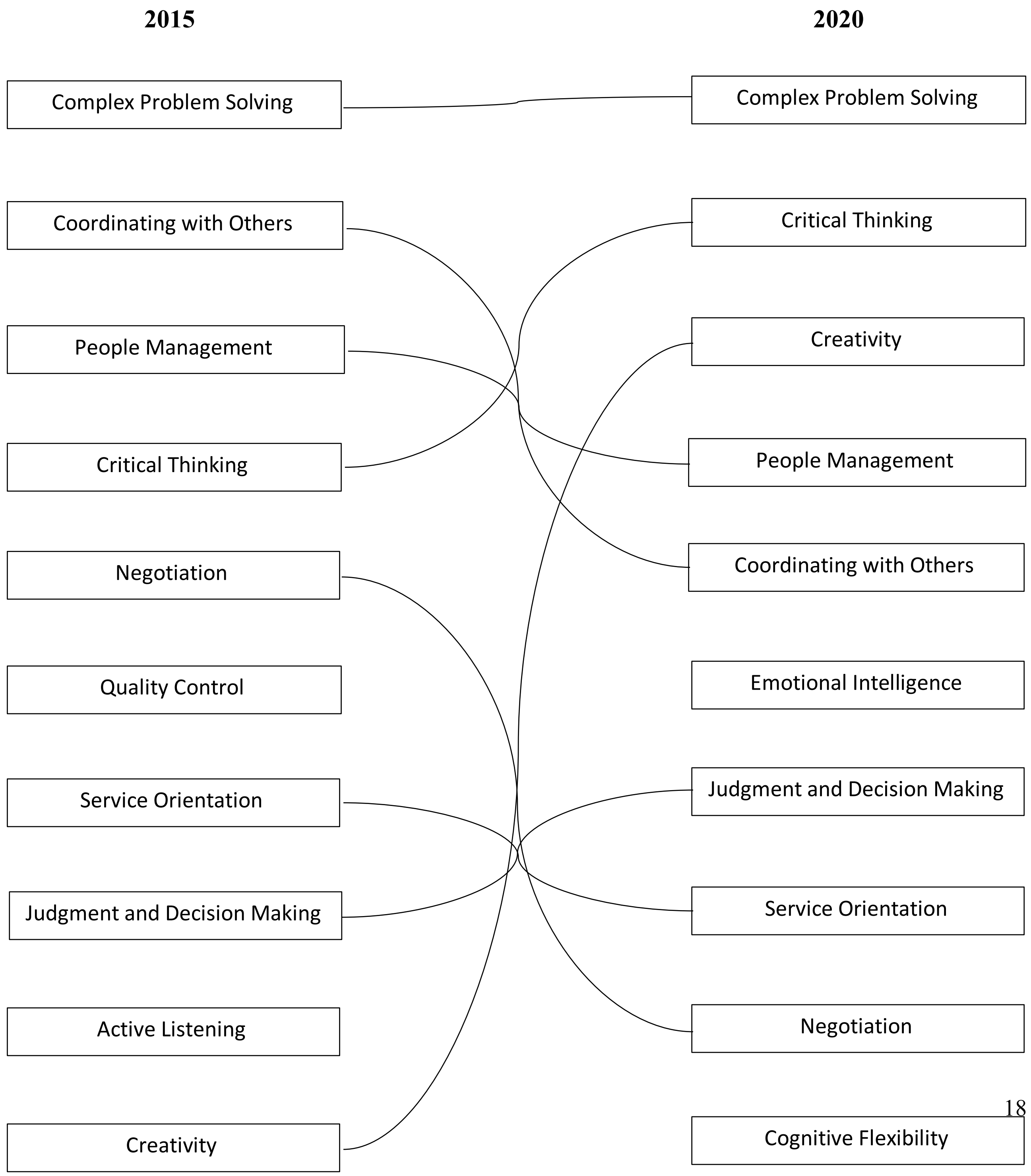
There are two main challenges for the 21st century:

- How to help existing workers acquire new skills and
- How to prepare future generations for a workplace with AI present

The World Economic Forum asked chief human resources and strategy officers from leading global employers what the current shifts mean, specifically for employment, skills and recruitment across industries and geographies.

The main results of the enquiry are shown in the following chart.

TOP 10 SKILLS



Creativity will become one of the top three skills workers will need. With the avalanche of new products, new technologies and new ways of working, workers need to become more creative in order to benefit from these changes. Emotional intelligence, which doesn't feature in the top 10 today, will become one of the top skills needed by all.

Today's job candidates must be able to collaborate, communicate and solve problems – skills developed mainly through Social and Emotional Learning (SEL).

Combined with traditional skills, this social and emotional proficiency will equip students to succeed in the evolving digital economy. To sum up what will become important for students' education in order to narrow the skill gap, the World Economic Forum has analysed the issue, finding that competencies are the means by which students approach complex challenges; they include collaboration, communication and critical thinking and problem solving. Character qualities are the ways in which students approach their changing environment; they include curiosity, adaptability and social and cultural awareness.

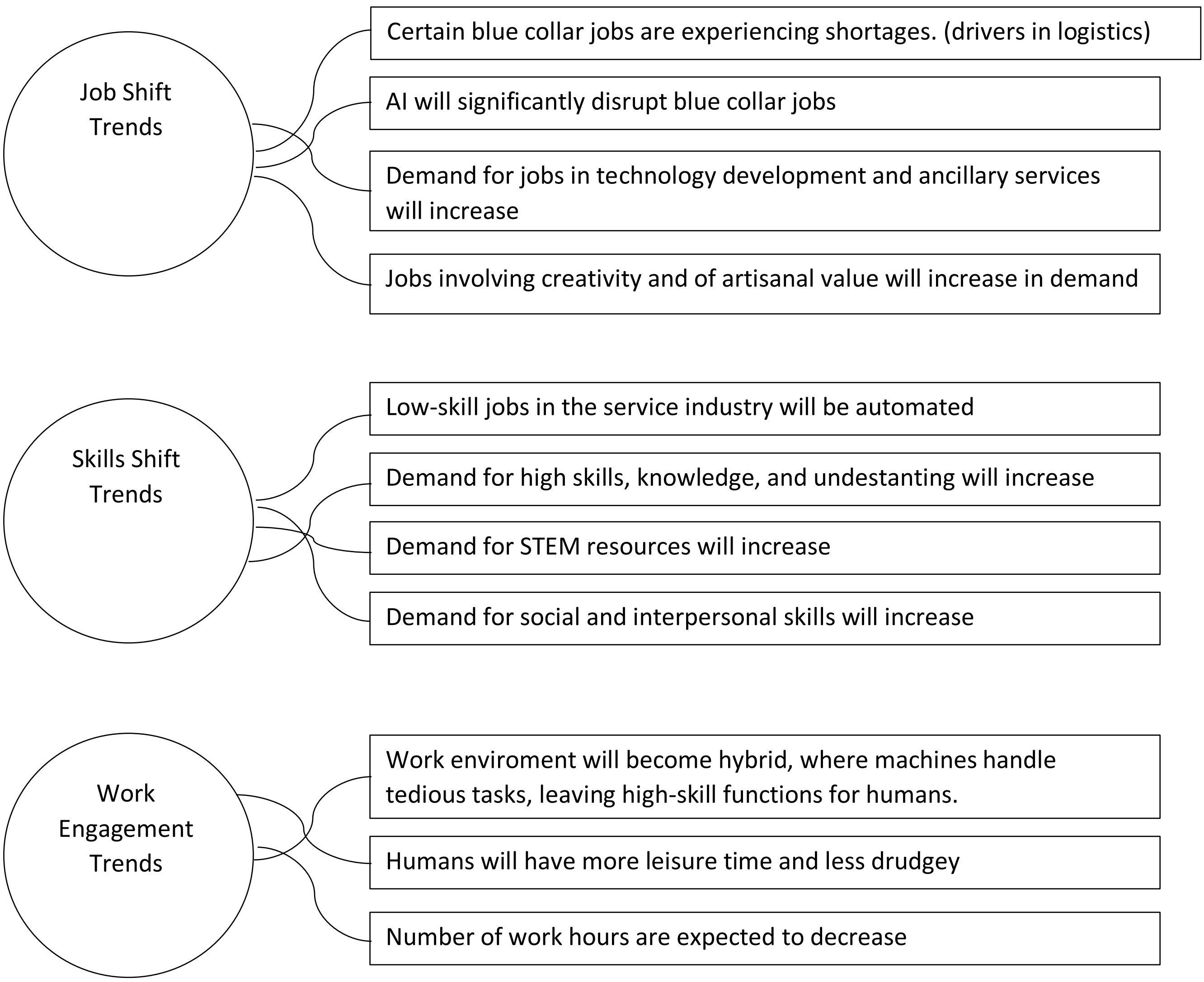
Some economists argue that the emerging labour market will require workers to be able to solve unstructured problems, work with new information and carry out non-routine manual tasks. That's true even for manual or administrative jobs, for which responsibilities now generally include much less routine labour and more digitized-nuanced communication.

Soft skills such as teamwork, knowledge of digital tools, and understanding of rules and regulations, responsibility and commitment, are the most relevant ones for the future.

6. The main trends of work in the future

Based on the previous analysis, we can outline in a chart the main trends in the change of occupations and jobs of the future.

There are many shifts taking place, regarding jobs, skills and work engagement.



Anyway, the expected future structure of the labour market is going to be the results of the many interactions between technology innovation, industrial strategies and business models, individual and social values and behaviours, public policies in the areas of welfare and economic development.

In order to achieve an evolution towards a model of work that is economically and socially accepted it is necessary to establish overall governance, which includes governmental institutions, entrepreneurs and their associations, trade unions and consumers that is able to design a comprehensive shared medium-long term vision of the economy and society.