Sommario

Is Italy equipped to face the coming age of robots? A comparison with Korea and Singapore

Abstract

At this stage of economic progress, technological improvements are very fast and affect deeply economic and social fabric. As far as labour market is concerned, a massive technological unemployment is expected to occur given that "robots" may substitute human beings. Therefore, public policy should deal with this new issue, trying to evaluate: a) if the use of artificial intelligence in production activities will open new job opportunities or increase unemployment; b) the way public policies may cope with this technological revolution. We provide a quick literature review on the expected effects of robots on employment and wages. Not surprisingly, empirical evidence is short and not unanimous, mainly since robots are not largely used yet (we are still in a virtual field). Nevertheless, even if to estimate the economic and social effects of robotization is premature (it is a far and complex scenario), data show that the coming of robotization in the long run may hardly be denied. Against this background, the general focus of this paper is on the institutional capabilities necessary to face robotization at best, for example the level and kind of investments in education and training as well as the quality of institutions. In particular, the Italian institutional context is compared with the Singaporean and Korean one, attempting to understand whether Italy is well equipped to challenge this technological revolution. The analysis is carried out applying the "Grounded Theory" approach (comparative analyses).

INTRODUCTION

Macroeconomic modelling is mostly focused on the achievement of two goals: "full employment" and "potential income" both by Keynesian and Neoclassical stream of economic thought. The cornerstone of any economic theory is "employment". Not surprisingly, John Maynard Keynes systematized Macroeconomics theory, in 1936, focusing on employment. Similarly, afterwards, neoclassical models ultimately aimed at resolving unemployment whatever its causes were. The employment policy, according to neoclassical theory, should attain greater labour market flexibility with a view to create perfect competition and solve the problem of unemployment by wage adjustments. According to this stream of economic thought, the institutional framework may hamper labour market flexibility. Whatever the perspective and the belief of economists, the simple point we want to highlight here is that any economic theory aims at resolving the problem of unemployment, even if it is "voluntary"; the debate concerns rather its causes.

The coming age of "robots" raises many questions about employment/unemployment. Some evidence shows that industrial robots may raise employment (Corlett A., 2016); some others describe their negative effect on employment and wages (Acemoglu D., Restrepo P., 2017). Against this background, the paper lays emphasis on the following argument: to estimate the economic and social effects of robotization is probably premature but the coming of robotization may hardly be denied. Therefore, governments and companies should think about how to face robotization in the future trying to control it rather than being mere bystanders. Consequently, the paper focuses on the

institutional capabilities which show to be useful to face robotization, for example government effectiveness and rule of law, as well as the general attitude of a context to acquire innovation and transform it in a great opportunity. Probably, this technological revolution will differ from the past ones but forecasting future scenarios including artificial intelligence is necessary and forward-looking.
The paper is organized as follows: first, we give some insights on scientists' point of view about the real evolution of robots and their possible employment in our societies. Second, we provide a brief review of the literature on the impact of technology on employment and some available data on the increasing use of robots in the industrial sphere. Then, by an interdisciplinary approach, we try to comprehend which kind of institutional context may challenge this extraordinary revolution.

1. What is "Artificial intelligence"?

The core difference between current and past technologies is due to the existence of "intelligent autonomous machines" which could gradually substitute the old automatic ones. Indeed, artificial intelligence does not function automatically but may imitate human behaviour and intelligence and act autonomously. The artificial intelligence is what is commonly called "robot". After industrial revolution, automation has basically consisted in making hardware components and software programs capable of functioning automatically. On the contrary, artificial intelligence might perform the cognitive capacities of human beings.
According to Lieto A., Bhatt M., Oltramari A, Vernon D. (2017):
In… [the] perspective, inspired by the cybernetics tradition and the synthetic method, the computational simulation of biological and cognitive processes is assumed to play a central epistemological role in the development and refinement of theories about the elements characterizing the nature of intelligent behaviour. In particular, such an approach has a twofold goal: i) it aims at detecting novel and hidden aspects of the cognitive theories by building properly designed computational models of cognition and ii) it aims at providing technological advancement in the area of Artificial Intelligence of cognitive inspiration.
In other words, scientists are studying "cognitive abilities", in order to understand, for example: *the ability to autonomously perceive, to anticipate the need for actions and the outcome of those actions, and to act, learn, and adapt* (Lieto A. et al., 2017) and be able to reproduce them artificially.
In addition, according to Veruggio G., Fiorella Operto (2016): *Synergies between robotics, neurosciences, medicine, education, and psychology, have broadened the scope of application of the latter, making robotics a platform of global scientific research on humankind, on our galaxy and on the interaction between humankind and nature*[1].
"Robotics" is a new science, since for the first-time scientists are endeavouring to create machines functioning intellectually and physically as human beings, an innovative experiment, still in progress. Therefore, the new technological revolution is quite different from the past ones. New hardware and software created in the past were not able to function without the strong intervention and supervision of human beings, instead artificial intelligence could work under a very limited supervision of human beings. This extraordinary technological advancement could open unthinkable scenarios and economists are properly worried about the possibility that labour, as now conceived, could become obsolete at best or useless at worst. Undoubtedly, high skills will be necessary to work with robots, thus confirming the concern that technology may influence the distribution of gains and losses, rather

[1]Veruggio G., Fiorella Operto (2016), Roboethics*: Social and Ethical Implications of Robotics*, Springer Handbook of Robotics.

than the level of employment. The notion of "creative destruction" is not new; Shumpeter formulated it in 1942 (Ilsøe, A., 2018)[2], stating that at the beginning the winners are the innovators and the losers are the old agents of production. However, may the introduction of artificial intelligence in the production process be compared to the past creative destruction? If we adopt a historical approach, it is highly probable that this innovation will produce winners and losers, but it would be quite unrealistic to foresee only losers.

In what follows, we are going to focus the analysis on the artificial intelligence employed in the production process. Indeed, within the general category called "artificial intelligence", the "industrial robots" may be distinguished: they do not require a human operator and can also be programmed to perform routine and manual tasks such as assembling, packaging, and painting[3]. The classification of a robot into industrial robot or service robot is done according to its intended application.

Robots may be used in several activities. Veruggio G., Fiorella Operto (2016) have listed lots of fields in which robots may be employed: *for example, ….for data sharing and cooperative working and learning…. in dangerous operations such as laying explosives; …. in the environmental protection (robots for pollution cleaning and decommissioning of dangerous facilities)…in urban rescue missions after catastrophes such as earthquakes, bomb or gas explosions….. in space travel and missions to explore the far planets of the solar system and beyond….in the operating theatre for years to help provide vital information through ultrasound, computer-aided tomography (CAT), and other imaging technologies.*

Given the enormous applicability of "artificial intelligence", the European Union is fostering enhancements in this field. Within Horizon 2020[4] EU has proposed to establish Public-Private Partnerships (PPP) in order to strengthen Europe's competitive position in specific business sectors. The goals of the Robotics PPP are:

1. Develop strategic goals of European robotics and foster their implementation;

2. Improve industrial competitiveness of Europe through innovative robotic technologies;

3. Promote position robotic products and services as key enablers for solving European societal challenges;

4. Strengthen networking activities of the European robotics community;

5. Promote European robotics;

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[2]Shumpeter (1942) described the process of creative destruction in its book, "Capitalism, socialism and democracy: *Capitalism, then, is by nature a form or method of economic change and not only never is but never can be stationary. And this evolutionary character of the capitalist process is not merely due to the fact that economic life goes on in a social and natural environment which changes and by its change….The fundamental impulse that sets and keeps the capitalist engine in motion comes from the new consumers' goods, the new methods of production or transportation, the new markets, the new forms of industrial organization that capitalist enterprise creates* (Shumpeter, 1942 p. 82-83).

[3]The "industrial robot" is officially defined by the International Organization for Standardization (ISO) as an automatically controlled, "reprogrammable" (whose programmed motions or auxiliary functions may be changed without physical alterations), multipurpose manipulator (capable of being adapted to a different application with physical alterations that is alteration of the mechanical structure or control system except for changes of programming cassettes, ROMs, etc.), programmable in three or more axes (direction used to specify the robot motion in a linear or rotary mode), which can be either fixed in place or mobile for use in industrial automation applications.

[4]Horizon 2020 is the financial instrument supporting the Innovation Union, a Europe 2020 initiative to foster Europe's global competitiveness. Running from 2014 to 2020 with a proposed indicative budget of €80 billion, the EU's new program for research and innovation is aimed at creating growth and employment in Europe.

6. Reach out to existing and new users and markets;
7. Contribute to policy development and addressing ethical, legal and societal issues.

Artificial intelligence is a developing scientific topic but it will be introduced in our life as soon as advancements go on, this is why European Union is promoting European robotics: if we do not deal with this technological revolution the impact upon our societies could be catastrophic.
The description of artificial intelligence provided above aims at reflecting on which kind of transformations it may produce in the economic system. Against this background, we are going to describe the literature about its probable impact on the labour market. Not surprisingly, the economic literature is not unanimous.

2. The impact of technology on employment: a brief review of the past literature

The impact of technology on unemployment has proved to be controversial, for several reasons, as for example, the definition and measurement of technological progress in economics. While the notion of unemployment is more straightforward, even if the related indicators may differ, the definition of technology and the methods to measure it are quite complex.
In economics, by definition, a technological change should bring about higher efficiency in the process of production and, consequently, an increase in output without using additional inputs (or conversely, a given output produced using less input). A technological change usually follows three steps:

- Invention – due to scientific discoveries;
- Innovation - the practical application of the invention for the first time;
- Diffusion - the widespread adoption of the innovation.

Usually, scientific advancements are applied to production processes, for example, in order to lower costs; to speed the time of production; to free human beings from hard works. Examples of new technology applications are planes, mobile phones, computers and internet. As a result, now it is easier to communicate, to move around the world or to spread information. Technology may be tangible (blueprints, models, operating manuals, prototypes) or intangible (consultancy, problem-solving, and training methods); in other words, you may have new objects performing old or new actions or new ways to organise and perform the production of old goods and services. In addition, technology affects culture and human behaviour, habit and customs (in two words institutional context): our life changes over time and more quickly than ever before. One good example of habit changes is the electronic communication.
Synthesising, technology is the sum of the knowledge accumulated in society, which may affect the "technical efficiency"[5]: the way resources are combined/used in production (technology and "technical efficiency" are not the same notion). Operationally, economists measure "technical efficiency" (and not technological progress), using ad hoc indicators and statistical strategy, such as, for example, the ratio between potential and current output for a given level of input. However, these indicators are not exhaustive proxies of technology[6]. In addition, technology and innovation are very

[5]The pioneering work on technical efficiency is by Koopmans (1951; p. 60) defined as follows: an input-output vector is technically efficient if, and only if, increasing any output or decreasing any input is possible only by decreasing some other output or increasing some other input.
Koopmans T. (1951), *Activity analysis of production and allocation*, John Wiley & Sons, New York.
[6]Three problems are faced in measuring "technical efficiency":
1. How many and which inputs and outputs are to be considered; and

close notions, often used to mean the same thing, but they are not synonyms. Innovation generated by the technological progress is often incorporated in human and physical capital and it is quite impossible to distinguish its specific contribution to the production activities. This issue has been the core of a long debate within the exogenous and endogenous growth theory; nevertheless, the impact of technological progress on economic growth remains not fully and clearly explained.

The goal of this preliminary discussion is to highlight how difficult may be to predict the impact of technological progress on unemployment, given that clear-cut and exhaustive proxies of technological progress are not available yet. Usually, economic growth is a good way of measuring indirectly the impact of technological change, adopting a definition of technology as the ability to perform better. Moreover, the economic theory states that growth is the result of the increase in the worker productivity. This idea is only partially true, as economic growth, in a globalized market, is the result of many synergic forces not always under the national government control, given that economic systems are more and more interlinked[7].

On the theoretical level, to analyse the impact of technology on employment, two hypotheses are traditionally at stake:

1. Technology may reduce employment by a substitution effect *(substitution theory)*: according to the supporters of this approach technology raises productivity and consequently the demand for labour diminishes[8];

2. The market mechanisms compensate in the medium run the negative impact of technology on employment (*compensation theory*). According to the supporters of this approach, technology – after the first negative impact on employment - should increase, in the medium/long run, the supply of innovative products and generate a slowdown of prices (and then wages). Therefore, in the medium run the demand for labour should increase, compensating its initial slowdown[9].

The *substitution theory* was criticized by Levy and Murnane (2004), sustaining that machine cannot perform complex tasks; but about ten years later Brinjolfsson and McAfee (2011, 2014) pointed out that machines are developing capacities going beyond the mere automation. From an empirical perspective, the literature does not converge on a single result. Coad and Rao (2011) approximate technological progress with the ratio of R&D expenditure and the numbers of patents to sales and find that technology has a positive impact on employment. Harrison et al. (2014) distinguish between product and process innovation (that is a good start)[10] and find that the innovation of productive processes determines the growth of productivity with a negative impact on employment, in the short run; but thereafter the demand for labour increases, compensating the initial negative impact. On the

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2. How to weigh them;
3. How to compute the potential output.

[7]For example, according to Hideaki Hirata et al. (2013), house prices are influenced by: i) the global variations of the interest rate; ii) credit market shocks; iii) uncertainty, measured by the global volatility of the share returns. Moreover, the level of synchronisation of real estate trends in advanced countries is increasing (passing from 51% in the pre-globalization,1971-1985, to 63% in the after-globalization, 1985-2011). It is a relevant issue as house markets may be drivers of growth and recession. The conclusion is that it is more difficult in a globalized world to capture by a well specified function the determinants of growth.

[8]Jeremy Rifkin (1995).

[9]The question is whether a free market is endowed with a *systematic mechanism that assures compensation within the Marshallian short period,* thus precluding any secondary distortions that could upset dynamic equilibrium" (Lowe 1976: 250).

[10]A product innovation is the introduction of a good or service that is new or has significantly improved characteristics or intended uses; a process innovation refers to the implementation of a new or significantly improved production or delivery method. Evidence from firm innovation surveys suggests that the share of firms with a product or process innovation varies significantly across countries and that firms often adopt mixed modes of innovation, meaning that they combine product and process innovations.

other hand, the product innovation produces immediately a positive impact on employment in those industries where the innovation is implemented.

In general, empirical evidence shows a greater positive impact of product innovation rather than process innovation on employment, but it is difficult to deduce a theory from these findings, for many reasons. First, the definition of technological progress is heterogeneous as well as the indicators used to measure it. Second, empirical surveys differ in geographical areas, dataset employed, industries analysed; therefore, it is impossible to generalise their findings.

In addition, the technology intensity varies a lot among industries. For example, manufacturing sector is more knowledge-intensive than the service sector, according to most empirical analyses[11].

Another stream of the literature highlights that technology may displace some jobs and create unemployment only in specific segments of the labour market, according to the kind of job performed (routine, manual or intellectual). These studies focus on the distributional effects of technological advancements and attempt to foresee the occupational categories at risk. In other words, the concern expressed in these studies involves the inequality potentially raised by technological progress rather than its impact on employment *tout court* (Piketty, 2014). Technological progress may affect the demand for skills by employer, due to the new ways required to perform old or new jobs. For example, Frey and Osborne (2013, 2017) highlight that digitalisation will reduce the demand for routine jobs. Similarly, Melanie Arntz et al. (2016) show that the demand for routine workers may diminish, but not by the same percentage for all countries. We could also derive a theoretical insight from these studies: capitalist system requires a constant upskilling of labour force. When productivity in agriculture speeded, the system required less workers for that sector who thanks to technological progress were employed in the manufacturer one. Afterwards, productivity in the manufacturer sector accelerated, requiring less workers who were employed in the service sector[12]. Future transformations of the economic system due to further technological progress non necessarily implies unemployment but only a different demand for skills. Therefore, to analyse the impact of robotization on the production systems, the first step may be to study which kind of transformations it is expected to produce and what skills workers are required to have for matching labour demand.

2.1 The impact of artificial intelligence on employment, some empirical results

Even if artificial intelligence is not extensively widespread, some studies on its impact is still available.

Acemoglu D., Restrepo P. (2017) observe the aggregate effect of industrial robots on employment and wages, in the U.S. labour market. The study underlines that the utilisation of robots in productive activities generates two opposite effects: the increase in productivity (positive) and workers' displacement (negative)[13], the level of which nevertheless varies across industries. Generally, the literature on the impact of the "artificial intelligence" upon the labour market is optimistic (IFR, 2017); even if some concern has been expressed about the displacement of low-skilled workers by robotization (Frey and Osborne, 2013). For example, Ljubica Nedelkoska and Glenda Quintini

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[11]For further details see: European Parliamentary Research Service (2018), The impact of new technologies on the labour market and the social economy, *Study IP/G/STOA/FWC/2013-001/LOT 8/C1 PE 614.539*, March.

[12]A very comprehensive analysis of all possible scenarios including artificial intelligence is outlined by Aghion et al. (2017). They stated that: Perhaps the automation of agriculture and manufacturing leads these sectors to grow rapidly and causes their shares in GDP to decline.

[13]Therefore, they confirm the Substitution theory.

(2018)[14] observe that the risk of automation decreases quite monotonically as a function of educational attainment and skill levels.
Graetz and M. Guy (2015) analyse a sample of 17 countries and conclude that robot densification (the number of robots per million hours worked) increased annual growth rate of GDP and labour productivity, between 1993 and 2007, by about 0.37 and 0.36 percentage points respectively. Other studies make forecasts on the possible impact of robots on productivity and economic growth, concluding that they bring about significant improvements at firms, industries and general economy level (Accenture, 2016; Boston Consulting Group, 2015; Barclays 2015).
Actually, multifactor productivity shows a diminishing trend in many rich countries, despite technological advancements (Tab. 1).

Tab. 1 - Multifactor productivity - annual growth rate (2010=100)

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Australia	1.49	-1.56	0.41	0.24	0.85	0.68	0.11	1.92	-0.12	0.87	-0.18
Canada	-1.01	-0.97	0.81	1.24	-0.19	0.85	1.93	-0.51	0.26	1.66	-0.11
France	-1.29	-2.00	0.91	0.76	-0.26	0.58	0.42	0.31	-0.12	1.62	0.76
Germany	-0.32	-4.06	2.43	2.47	0.24	0.19	1.04	0.64	1.21	1.18	0.10
Italy	-1.27	-3.30	1.75	0.41	-1.39	-0.01	0.06	0.24	0.04	0.85	-0.14
Sweden	-2.59	-3.90	3.37	0.43	-0.94	0.29	0.89	2.11	-0.19	0.12	
Great Britain	-0.59	-3.37	1.62	0.01	-0.54	0.22	-0.10	1.29	-0.50	0.72	0.21
Japan	-0.88	-2.61	3.44	0.08	1.00	1.86	-0.05	1.05	-0.11	1.47	0.16
Korea	3.53	1.57	4.65	1.65	0.28	1.14	1.18	0.46	1.51	2.56	2.02
New Zeland	-3.99	3.35	-1.44	1.08	2.25	-1.89	-0.51	1.94	-0.41	-1.57	-0.01
USA	-0.16	1.15	1.87	-0.22	0.12	0.07	0.31	0.63	-0.12	0.70	0.63

Source: OECD data, Multifactor productivity (indicator).

An interesting point of view is expressed by Gordon (2012) highlighting that *the rapid progress made over the past 250 years could well turn out to be a unique episode in human history*. He identified three industrial revolutions. The first one, from 1750 to 1830, is characterised by steam and railroads; the second one, from 1870 to 1900, produced the birth of electricity, internal combustion engine, running water, indoor toilets, communications, entertainment, chemicals, petroleum; finally, the third one, from 1960 to the present time, may be defined as the era of communication technology. According to Gordon (2012) the second industrial revolution engendered 80 years of relatively rapid productivity growth between 1890 and 1972, then, productivity growth during 1972-96 was much slower than before. The third revolution produced a significant productivity growth only between 1996 and 2004. He concluded that in U.S. even if innovation persists in the future, productivity will grow much slower than before 2007, listing the principal causes of this phenomenon: demography, education, inequality, globalization, energy/environment and consumer and government debt. Gordon's analysis (2012) shows that not every kind of technological progress has the same impact on productivity and not every country reacts in the same way to it. It depends upon the nature of a specific technological advancement and the way it may change economic and social fabric.
OECD (2015) pointed out that technological innovation must be supplemented by investments in "knowledge-based capital", otherwise firms are not able to take advantage of it. Other reasons, which may explain the productivity slowing down, are discussed in OECD (2016) and relate to the 2008

[14]Ljubica Nedelkoska, Glenda Quintini (2018), Automation, skills use and training, OECD Social, Employment and Migration Working Papers No. 202.

financial crisis, namely skill mismatch, sluggish investments, and declining business dynamism. This trend is called in the literature "*the paradox of productivity*".
Actually, we are at the beginning of the third revolution (artificial intelligence) whose effects have not fully disclosed yet. In addition, up to now the labour market has always adjusted to the substitution of labour with capital; in particular, prices have tended to balance the forces of automation and new complex paid jobs have been created. The December 2016 US White House report on artificial intelligence and automation stated that (McKinsey Global Institute, 2017):
Recent research suggests that the effects of AI on the labour market in the near term will continue the trend that computerization and communication innovations have driven in recent decades… The economy has repeatedly proven itself capable of handling this scale of change, although it would depend on how rapidly the changes happen and how concentrated the losses are in specific occupations that are hard to shift from.
Similarly, the Business, Energy and Industrial Strategy Committee of the House of Commons (2019)[15], in UK, published a Report about "Automation and the future of work" to analyse the current situation in their country. It is interesting to cite how it begins: *The problem for the UK labour market and our economy is not that we have too many robots in the workplace, but that we have too few. If we fall further behind in productivity and the adoption of new technologies, then future investment decisions will not follow.* Therefore, the Committee expressed a different point of view: the adoption of new technologies is a way for economic and social progress. Indeed, in the Report, the pessimistic literature about the impact of robots on employment is quoted and the data of the UK Office for National Statistics showed. According to these data 7.4% of UK workers may be at high risk of automation, while 64.9% of workers at medium risk. Nevertheless, the authors of this Report stated that (p. 7): *Rather than producing a further study that warns of the effects that automation could have and adds to concerns, we have undertaken this inquiry to examine how businesses, workers and the Government should prepare for and manage this transition, and to consider the UK's current and potential strengths in the automation sector.*

Concluding, any hypothesis on the future scenarios determined by "artificial intelligence" requires great caution, but robotization will come and governments must be ready for this great challenge. In addition, there seems to be a consensus around education and training attainments as key tools to cope with any kind of technological progress.

3. The current diffusion of robots, a special look to Italy, Singapore and South Korea

We are going to describe to what extent robots are spread in productive activities. However, being a very new science frontier, still in progress, few data are available.
The international federation of robotics (IFR) publishes quite regularly some data on artificial intelligence by industries and countries, estimating also the future developments. We are going to focus our analysis on Italy and two Asian countries, South Korea and Singapore, which show the greatest diffusion of robots in manufacturing industry (Tab. 2). In addition, Italy shows a relatively high diffusion of artificial intelligence compared to most European countries. The reason of this choice is due to the fact that if in Korea and Singapore artificial intelligence is more widespread we may already observe the reaction of economic system to it and the performance of labour market, in order to draw some suggestions for the Italian policy making.

[15]House of Commons Business, Energy and Industrial Strategy Committee (2019), Automation and the future of work Twenty-third Report of Session 2017–19, Published on 18 September by authority of the House of Commons.

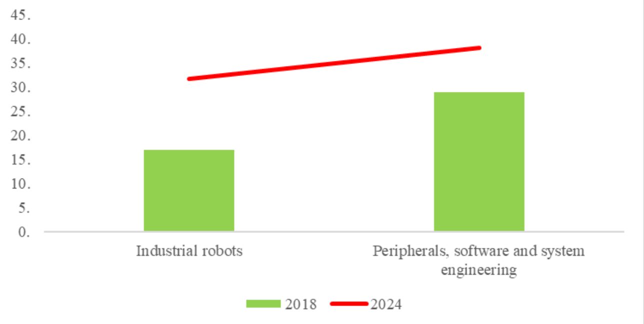
Against the global average of industry-related robot density equal to 99 units per 10,000 employees, Singapore and South Korea show respectively 831 and 774 units, while Italy 200 units. In addition, while the unit shipments of industrial robots in South Korea are equal to 37,800, in Italy they are 9,800 and in Singapore 4,300. Italy ranks second in Europe, after Germany but before France and Spain.

Tab. 2 - Manufacturing industry-related robot density in selected countries - 2018 (in units per 10,000 employees)	
Singapore	831
South Korea	774
Italy	200
Global average	99
Unit shipments of industrial robots worldwide in 2018, by country (in 1,000s)	
South Korea	37.8
Italy	9.8
Singapore	4.3

Source: IFR World Robotics Presentation 2019, page 7

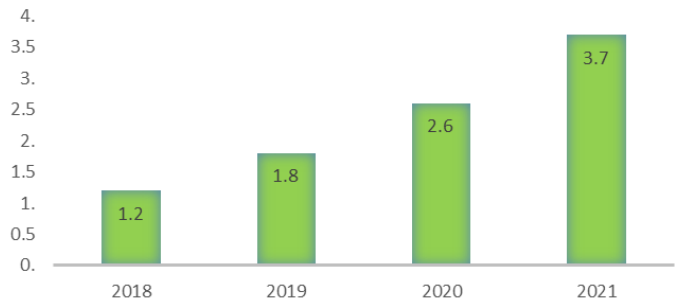
Figure 1 shows that the market size for industrial robots and other kind of artificial intelligence is expected to increase from 2018 to 2024. The market size for industrial robots should reach the value of 31.7 billion US dollars in 2024 against 16.9 billion US dollars in 2018; it is thus expected to double. Software and system engineering should pass from 28.8 billion US dollars in 2018 to 38.1 billion US dollars in 2024.

Fig. 1 - Global size of the market for industrial robots and peripherals in 2018 and 2024 (in billion U.S. dollars)



In addition, the worldwide demand for advanced robotics in manufacturing industry, between 2018 and 2021, is expected to raise. This is a sign that industrial robots are going to be used more and more in productive activities worldwide, even if this demand will vary a lot across countries (Fig. 2).

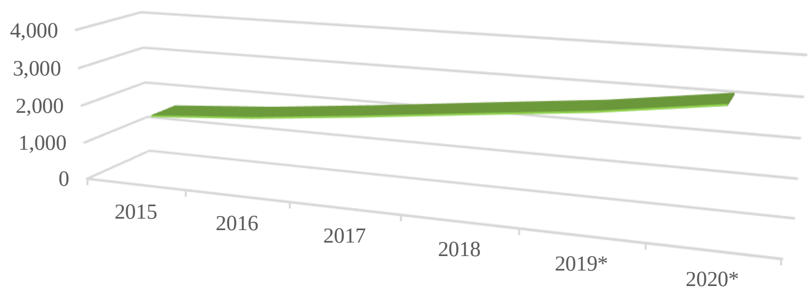
Fig. 2 - Projected demand for advanced robotics in manufacturing worldwide between 2018 and 2021 (in billion U.S. dollars)



Source: IFR, Advanced Robotics in the Factory of the Future, exhibit 1

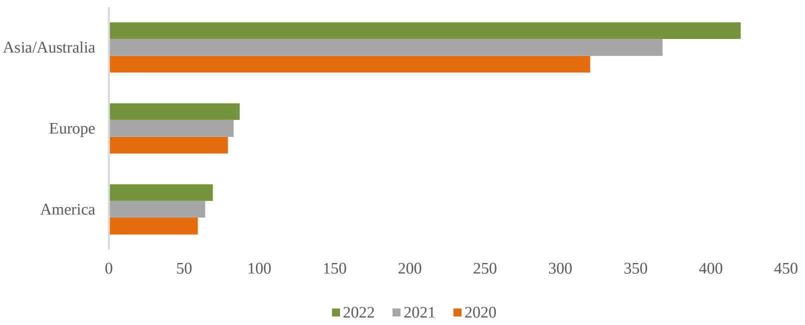
The worldwide operational stock of multipurpose robots is increasing as well, changing from 1,632,000 units in 2015 to 2,440,000 in 2018. It is expected to reach the value of 3,152,000 units in 2020.

Fig. 3 - Operational stock of multipurpose industrial robots worldwide 2015-2020 (in 1,000 units)



Finally, data shown in Figure 4 on the estimated industrial robot installations across macro-regions disclose clearly that Asia and Australia will be well forward, while Europe and America will lag. Nevertheless, industrial robot installations are increasing over time in all the geographical areas.

Fig. 4 - Estimated annual industrial robot installations in selected regions from 2020 to 2022, by main region (in 1,000 units)



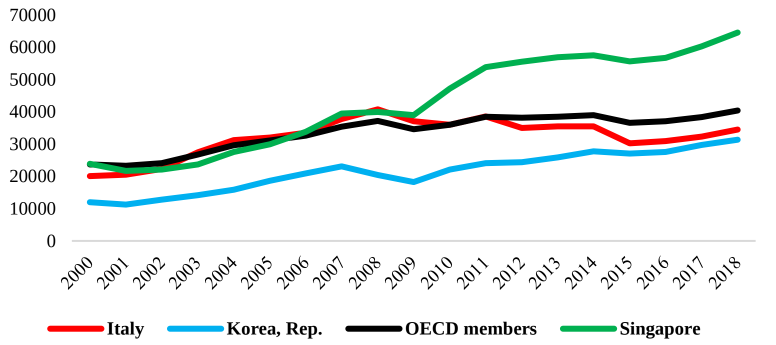
Source: IFR World Robotics Presentation 2019, page 7

Data show that the diffusion of robots in productive activities is forecasted to follow a positive trend. On these bases, the focus of the analysis will be, in the following sessions, about the institutional capabilities necessary to make artificial intelligence a great opportunity and prevent it to have a negative impact on economic and social system. We are going to show that a high propensity to innovate and market openness in terms of trade and knowledge may help countries to cope with the diffusion of artificial intelligence. The "propensity to innovate" means here: high investments in human capital and R&D; knowledge exchange with foreign countries; strategic alliances among firms to cope with technological advancements (networking); private and public partnership in education and training. The propensity to innovate may flourish if institutions and organisations show some quality characteristics which will be described in what follows.

4. Economic performance and the level of innovation in Italy, Singapore and South Korea

In 21st century, Asia is the innovation *hotbed* of the world, abreast of Northern American and some European countries (Germany and Scandinavia). In the Asian continent, Japan has confirmed its role of driving force of global innovation, since 1970, but starting from the 80s, other countries have emerged: Hong Kong (China), Singapore, the Republic of Korea, and to some extent Malaysia. They all represent the top Asian countries for innovation. In particular, Japan and the Republic of Korea have created, in Asia, innovation networks in technology-intensive manufacturing sectors; even if they still act as strategic tools to outsource manufacturing activities in low-cost areas rather than to spread innovation (Cornell University, INSEAD, and WIPO, 2017).
We are going to compare Italy with Korea and Singapore (two Asian countries where artificial intelligence is more widespread) and attempt to analyse the way institutional context react to automation, starting from some general data on their economic performance.
Financial and economic crisis hit every country to different extents. Italy shows a decreasing per capita GDP from 2008 and a slight recovery from 2015, while Korea and Singapore recovered sooner, respectively in 2011 and 2010 (Fig. 5). Interestingly, Korean per capita GDP is increasing all over the period, except for the years of crisis 2007-2009, converging to the Italian per capita GDP during last years. Similarly, the Singaporean per capita GDP increases all over the period except for the years of crisis and in addition shows a significative upturn from 2011 onwards, outstripping not only the Italian per capita GDP but also the OECD average one.

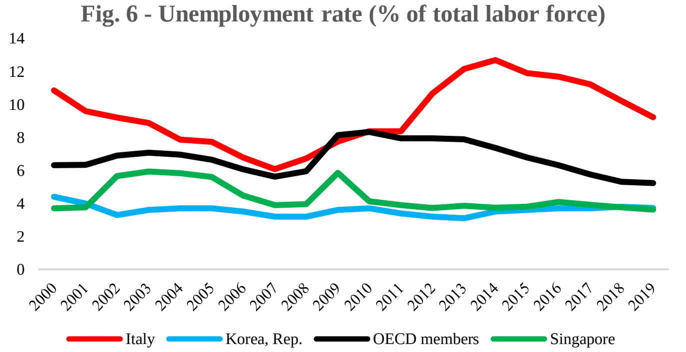
Fig. 5 - Per capita GDP 2000-2018 (current U.S. dollars)



Source: World Bank data

In addition, the level of unemployment as a percentage of total labour force is quite high in Italy, equal to 10.2 in 2018 and 9.2 in 2019, while it is moderate in Korea and Singapore which show the same rate (3.6%) in 2019. The unemployment rate is always higher in Italy than in Korea and Singapore, even if the Italian per capita GDP, from 2000 to 2009, is higher than the Korean one and almost equal to the Singaporean one (Fig. 6)[16]. Italian labour market, therefore, exhibits the worse performance among the selected countries both during positive and negative cycles. Therefore, unemployment in Italy is structural and not only dependent from the economic cycle. On the other hand, the unemployment rate exhibited by Korea and Singapore is low enough to be deemed frictional, given the growth of their per capita GDP.

Fig. 6 - Unemployment rate (% of total labor force)



Source: World Bank data

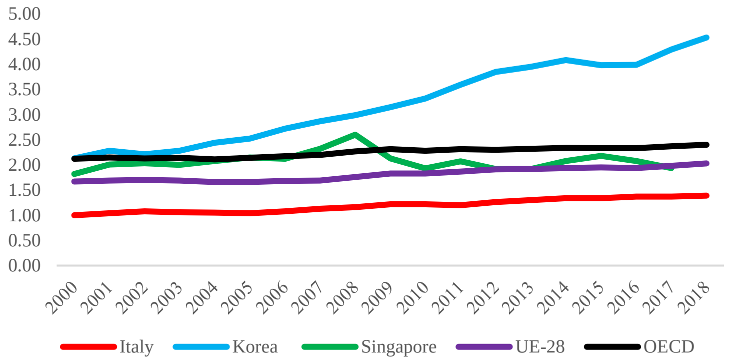
The economic performance of these countries is the result of past and recent policies, which are described in the next section in order to investigate the key elements of institutional capabilities to face technological revolutions. The first insight derived by data concerning the per capita GDP and the unemployment rate is that Italy has old and structural economic problems which have not been resolved yet and do not depend upon technological progress.

As far as innovation is concerned, first we show some data on the R&D expenditure in the selected countries, one of the gauges of the innovation environment. The gross domestic spending as a

[16] https://data.worldbank.org/indicator/SL.UEM.TOTL.ZS?locations=IT-KR-SG.

percentage of GDP in Korea leaves behind not only Singapore and Italy, but also the OECD and UE-28 countries. The R&D expenditure for Singapore was about the OECD average up to the 2008 crisis, then it fell under it. UE-28 in general but especially Italy exhibit a lower gross domestic spending compared to OECD countries average.

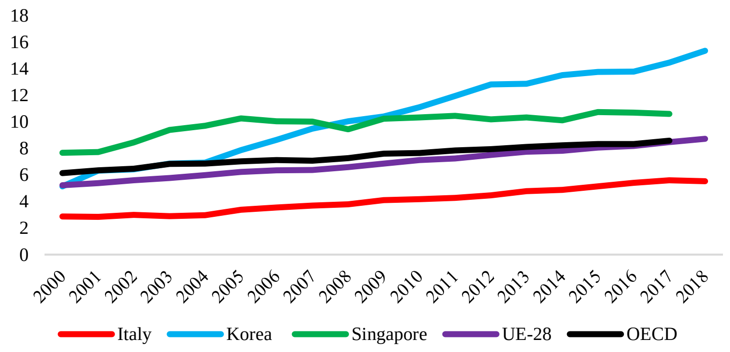
Fig. 7 - Gross domestic spending on R&D (% GDP)



Source: OECD

Finally, the number of researchers for 1,000 employed show the same picture, even if Singapore in this case exhibits a more positive trend than the OECD average. Italy exhibits the worst performance in relation to the number of researchers.

Fig. 8 - Researcher (1000 employed) 2000-2018



Source: World Bank data

However, the gross domestic spending on R&D is not an exhaustive indicator to establish the level of innovation reached by countries. Innovation is a complex notion involving the whole economic and social system, not to mention the institutional evolution of a country. Innovation involves three distinct capabilities: discovery, incubation and application. Firms should develop the ability to apply innovations to their business model, in order to create new processes and/or products/services as well as new schemes of organisation. This ability to transform innovation in new opportunities of

production requires supplementary resources to the R&D expenditure. Therefore, a strong willingness to innovate presumes a significative return to investments in R&D. Moreover, it is quite difficult to measure the return to investments in R&D[17], consequently it may be underestimated by firms.

An attempt to comprehend all the possible aspects of innovation is made by Cornell University, INSEAD, and WIPO (2019) who built The Global Innovation Index 2019[18]. This index covers a wide range of innovation drivers, over the period 2016-2018, and involves 129 countries in the world. According to Cornell University, INSEAD, and WIPO (2019)[19], the top three countries in Europe are Switzerland, Sweden and Netherland; in North America they are US and Canada; finally, in Asia they are Singapore, the Republic of Korea and China. Italy ranks 31st, while Singapore and Korea rank respectively 5th and 12th. In Tab. 3, the scores for macro-innovation inputs and outputs are shown. As far as innovation inputs are concerned Italy exhibits the worst scores in Business sophistication[20] and Human capital and research. Several years of stagnation in R&D expenditure has resulted in a progressively deterioration of human capital and education and research system. Contrarily, Korea ranks first for Human capital and research while Singapore ranks fifth, which – nonetheless - is a good position if compared to Italy. However, an interesting topic to be discussed refers to Institutions[21]. Singapore is a small economy, but it ranks first for Institutions, which means that it has an excellent institutional context encouraging innovation, as well as a good regulatory quality, fostering the start of business. The weakness of Italian institutional context depends upon Political and operational stability, Government effectiveness and Rule of law (Cornell University, INSEAD,

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[17]For a review of the literature on this topic see: Mohnen P. (2019), R&D, innovation and productivity (chapter written for the Handbook of Economic Performance edited by Bill Green and Thijs ten Raa), Maastricht University and UNU-MERIT WP N. 7, April 20.

[18]It is a composite index which capture all the fundamental variables of innovation: namely, Institutions (political, regulatory and business environment); Human capital and research (Expenditure on education; Government funding per secondary student; School life expectancy; Assessment in reading, mathematics, and science; Pupil-teacher ratio, secondary); Tertiary education (Tertiary enrolment; Graduates in science and engineering; Tertiary inbound mobility); Research and development (Researchers, full-time equivalent; Gross expenditure on R&D; Global R&D companies, average expenditure, top 3; QS university ranking average score of top 3 universities); Infrastructure (Information and communication technologies (ICTs); General infrastructure); Ecological sustainability (GDP per unit of energy use; Environmental performance; ISO 14001 environmental certificate); Market sophistication (Credit; Investment in the financial market); Trade, competition, and market scale; Business sophistication (Knowledge workers; Innovation linkages; Knowledge absorption); Knowledge and technology outputs (Knowledge creation; Knowledge diffusion); Creative outputs (Intangible assets; Creative goods and services; Online creativity).

[19]The Global Innovation Index goes forward every year, including new data and the progressing results of theoretical and empirical research on innovation. This year the GII model includes 129 countries/economies, which represent 91.8% of the world's population and 96.8% of the world's GDP in purchasing power parity current international dollars. The GII relies on two sub-indices—the Innovation Input Sub-Index and the Innovation Output Sub-Index—each built around pillars. The Innovation Input Sub-Indexes attempt to highlight the elements of the economic system fostering innovative activities, while Innovation Output Sub-Index the results of innovative activities within the economy.

[20]This indicator includes joint venture strategic alliance deals (billion PPP dollars GDP), High-Tec imports as a percentage of total trade and FDI net inflows as a percentage of GDP. A strategic joint venture is a business agreement between two companies who make the active decision to work together, with a collective aim of achieving a specific set of goals and increase their respective bottom lines. Through this arrangement, the companies effectively complement one another's strengths, while compensating for one another's weaknesses. Both companies share in the returns of the joint venture, while equally absorbing the potential risks involved.

[21]This indicator includes Political and operational stability, Government effectiveness, Rule of law, Regulatory quality, Cost of redundancy dismissal (salary weeks).

and WIPO, 2019). Indeed, the obsolescence of the Public Administration, the ongoing internal strife which undermines political parties' credibility, the lengthiness of the judicial system are important barriers to the diffusion of innovation and business creation (Hinna A. 2016)[22]. Not surprisingly, Italian innovation outputs, which measure the impact of knowledge and technology on markets, show a lower value/score than the Korean and Singaporean ones (Table 3).

Tab. 3 - Global Innovation Index (Italy, Korea, Singapore)

Global Innovation Index 2019	**Italy**		**Korea**		**Singapore**	
Input and outputs	Score/value	Rank	Score/value	Rank	Score/value	Rank
	Input pillars					
Institutions	75.3	34.0	79.7	26.0	94.9	1.0
Human capital and Research	45.4	31.0	66.5	1.0	63.0	5.0
Infrastructure	59.4	22.0	61.6	15.0	65.4	7.0
Market sophistication	51.4	50.0	64.3	11.0	73.6	5.0
Business sophistication	42.2	29.0	57.6	10.0	63.9	4.0
	Output pillars					
Knowledge and technology outputs	38.9	22.0	50.2	13.0	50.9	11.0
Creative outputs	36.8	37.0	44.1	17.0	38.3	34.0

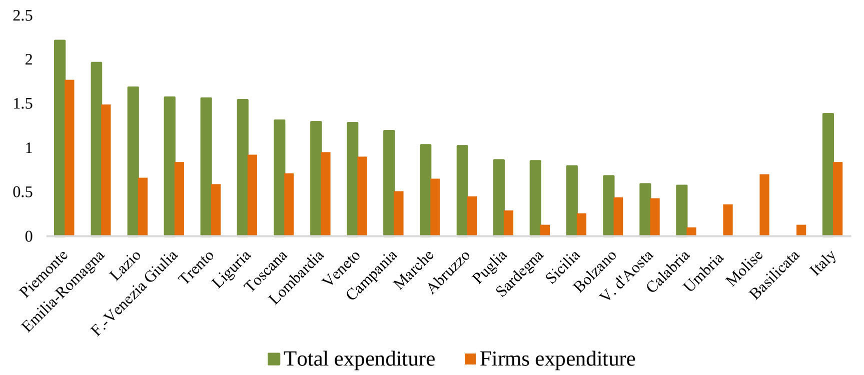
The key innovation drivers for Korea and Singapore are respectively Human capital and research and Institutions. Looking at Korea and Singapore as best practices, we may observe that investments in R&D as well as the creation of a favourable environment for innovation are accompanied by economic and employment growth. These countries do not seem hampered by the advancing of artificial intelligence, by now.
In addition, The Global Innovation Index 2019 gives key elements of reflexion about Italian innovation gaps. Nevertheless, Italy is a confederation of regions, which are very different in their economic and social performance, therefore in the next paragraph we are going to give some insights on the regional attitudes towards innovation.

4.1 Italian regional propensity for innovation and the possible impact of artificial intelligence

Over the period 2014-2016, the Northern area of Italy (except for Valle D'Aosta) shows a general propensity for innovation higher than the Southern area of the country.
Indeed, in 2016, the North-West area of Italy shows the highest share of R&D expenditure. In particular, the regions which exhibit the highest R&D expenditure as a percentage of regional GDP are Piemonte and Emilia-Romagna. As far as business enterprises expenditure is concerned, Piemonte, Emilia-Romagna and Lombardia rank in the first three positions (Fig. 9).

[22]Hinna A. et al. (2016), La pubblica amministrazione in movimento, Competenze, comportamenti e regole, Egea editore.

Fig. 9 - Gross domestic spending on R&D by regions (% GDP) - 2016



Source: Istat, ASI 2018

Over the period 2012-2015, intramural R&D funded by public institutions and universities diminished, while intramural R&D funded by private non-profit institutions and business enterprises is increasing (Tab. 4). Data show a clear picture: total intramural R&D is slightly augmenting but the composition of funding by institutions is changing. Firms are replacing – even if slowly - public institutions (Tab. 4). In particular, intramural R&D financed by business enterprises in Piemonte, Lombardia, Veneto and Emilia-Romagna accounts for 67.3% of the total amount financed in Italy by business enterprises. Whereas, intramural R&D financed by public institutions in Lazio accounts for 42.3% of the total amount financed by public institutions in Italy. Therefore, Lazio, a region located in the Centre of Italy, ranks third, but thanks to public institutions' funding.
Not surprisingly, innovative firms are mainly located in the North, namely in Piemonte, Lombardia, Liguria, Veneto and Friuli-Venezia-Giulia (Fig. 10). Since the end of the II World War, industrial sector has been developing in the North area of the country. Up to 1980, the North-West has played a key role, especially in exports, then the North-East has started to compete with the North-West and to acquire a share of exports. The South of Italy and the Centre contributed very little to the industrialisation of the country. Therefore, firms investing in innovation find a more favourable environment in the North rather than in the South and the Centre of the country, given the diverse economic and institutional fabric[23].

Tab. 4 - Intramural R&D by regions, financed by government, universities, private non-profit institutions and business enterprise - 2016, (Thousand euros)

ANNI REGIONI	Aggregate values				
	Public Institutions	Universities	Private non-profit institutions	Business enterprise	Total
2012	3,040,406	5,747,760	607,114	11,107,205	20,502,485
2013	2,937,418	5,938,235	627,059	11,480,390	20,983,102
2014	2,959,783	5,815,921	661,798	12,343,773	21,781,275

[23]Corruption and the presence of organised crime are often cited as institutional gaps of Southern Italian regions. They are without any doubt important obstacles to development. In addition, a lack in social capital has been underlined as possible explanation of the gap between Northern and Southern Italian regions (See for example Helliwell, J., & Putnam, R., 1995). Nevertheless, this topic is very huge and would require adequate space to be investigated properly.

2015	2,910,618	5,653,047	706,890	12,886,403	22,156,958
By regions - 2016					
Piemonte	99,629	388,860	79,427	2,296,561	2,864,477
Valle d'Aosta	1,207	3,718	2,218	19,167	26,310
Liguria	153,648	139,540	8,602	447,198	748,988
Lombardia	236,309	765,145	255,260	3,500,769	4,757,483
Trentino-Alto Adige	80,122	127,805	29,251	208,369	445,547
Bolzano	*1,620*	*29,953*	*22,228*	*97,175*	*150,976*
Trento	*78,502*	*97,852*	*7,023*	*111,194*	*294,571*
Veneto	93,754	482,887	15,695	1,396,844	1,989,180
Friuli-Venezia Giulia	100,717	162,250	6,009	312,462	581,438
Emilia-Romagna	192,942	527,802	13,732	2,288,376	3,022,852
Toscana	152,732	506,982	24,435	794,489	1,478,638
Umbria	15,920	130,575	*	76,071	*
Marche	15,238	139,773	219	263,711	418,941
Lazio	1,232,801	588,450	67,850	1,238,158	3,127,259
Abruzzo	39,726	136,403	1,529	143,775	321,433
Molise	1,925	18,745	*	42,855	*
Campania	180,882	514,507	32,332	544,382	1,272,103
Puglia	82,726	297,645	22,903	202,895	606,169
Basilicata	28,755	24,193	*	14,911	*
Calabria	17,162	137,815	419	31,520	186,916
Sicilia	117,376	332,765	12,892	224,026	687,059
Sardegna	67,756	171,052	1,053	41,657	281,518
North-West	**490,793**	**1,297,263**	**345,507**	**6,263,695**	**8,397,258**
North-East	**467,535**	**1,300,744**	**64,687**	**4,206,051**	**6,039,017**
Centre	**1,416,691**	**1,365,780**	*****	**2,372,429**	*****
South	**351,176**	**1,129,308**	*****	**980,338**	*****
Isles	**185,132**	**503,817**	**13,945**	**265,683**	**968,577**
ITALY	**2,911,327**	**5,596,912**	**575,177**	**14,088,196**	**23,171,612**

Source: Istat, Annuario Statistico Italiano 2018

Artificial intelligence may give the final blow to the Southern and Central regions, but also the North may be damaged, since the general level of innovation in Italy is very low[24]. If policy makers do not consider the potential of Artificial Intelligence and the digital transformations needed by firms to survive in a fast-moving world, Italy has a little chance to improve its competitiveness. In other words, ignoring the potential of artificial intelligence may represent a missed opportunity. Indeed, according to the American Chamber of Commerce in Italy (2019) artificial intelligence may give a great stimulus to economic growth. Surveying ten industries[25], which account for 77% of the total Italian turnover produced in 2017, they investigated the expected impact of artificial intelligence on them. The potential of artificial intelligence was computed measuring the annual revenue growth by 2030 due to the investments in artificial intelligence. The findings of this survey are quite interesting and are as follows:

- The potential of artificial intelligence may change significantly by industrial sectors.
- Industries which invest in artificial intelligence might grow up to 2.8% more than non-investing companies and their value-added is expected to grow up to 5.3% more than non-investing companies.
- Artificial intelligence may be profitable only if companies show the following characteristics: strategic vision, talent readiness, project governance, project maturity (ability of companies

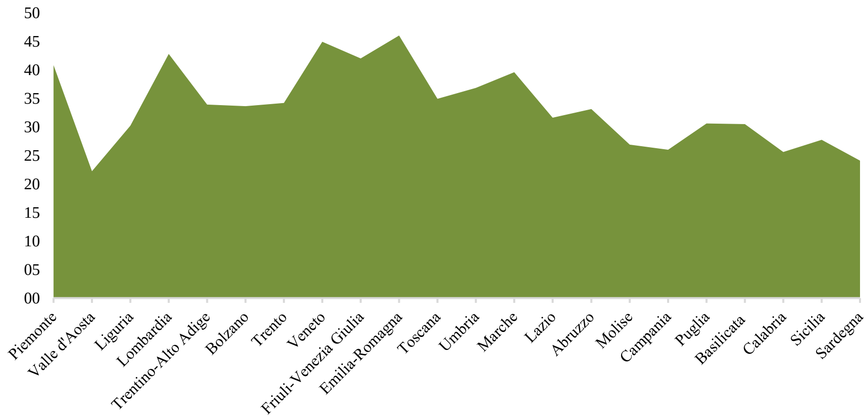
[24]See Section 4.

[25]They are: Telecom and high tech, financial services, automotive and assembly, consumer packaged goods, energy, transport and logistics, retail, travel and tourism, professional services, and construction.

to approach AI projects as immediately operational), cybersecurity/data privacy (compliance with the most advanced standards related to this area), capital adequacy, and ecosystem role.

The interviewed companies carrying on artificial intelligence projects underlined that tools and algorithms may help to establish a more efficient relation with customers and promote a significative upskilling of workers through "learning by doing". However, the interviewed companies have also identified two possible risks related to artificial intelligence projects: the maintenance costs (namely *process alignment*, *IT integration and training*) and the impact on employees. Finally, an interesting result of this survey is that companies, which have already undergone artificial intelligence in their activities, perceive a lower risk (by almost 50 percent) than the remaining ones. This result suggests that the perception of the damages provoked by artificial intelligence and a negative attitude towards innovation (without experimenting its possible potential) may play a key role in determining the impact of any technological adavancement upon employment and economic growth. In other words, the institutional context (economic and social fabric, habit, customs, culture, history, level of education, rule of law, government effectiveness) may have a key role in determining the impact of technological advancements on the economic system of a country.

Fig. 10 - Innovative* firms by regions (% total firms) - 2016



Source: Istat, NoiItalia 2018

* Firms introducing innovative products or processes

Therefore, in the next section, we are going to analyse the determinants of innovation in Korea and Singapore in order to find out possible shortcomings in the innovation propensity of Italy. The inshight derived by data is that a high propensity to innovate may smooth out the impact of technological progress on labour market, even in the short run. In other words, the innovation propensity may be crucial to cope with the huge changes which artificial intelligence may bring about in our economic and social life.

5. How Korean and Singaporean institutional contexts foster innovation and the Italian shortcomings

The idea to build a theory explaining the determinants of innovation is very old (Lundvall, 1992) and not surprisingly the interest in this subject renewed just when globalisation started to establish its rules more strongly. Over 2000, several research projects have dealt with the key elements explaining

the propensity to innovate. This discussion has highlighted the complexity of the notion of innovation and the difficulties to reach a definitive theoretical definition. However, at least a conclusive agreement has been accomplished: the main components of innovation systems are institutions (for examples, habit, rules, culture, history) and organisations (e.g. firms, agencies, research bodies, universities)[26]. A multiform interplay between institutions and organisations may facilitate or hinder innovation. Institutions affect organisations, but in turn organisations might influence institutions. The attempt to straighten up this intricate game is very ambitious.

In the globalised world, the creation of environments open to innovation should be a key element of public policy, given the increasing competition. Data analysed in the previous sections show that countries where innovation investments are crucial elements of economic policies (R&D expenditure, education and training investments, market openness aimed at the acquirement of technological advancements, cooperation with neighbouring economies), are also countries exhibiting a good economic performance. In countries such as Korea and Singapore where technological progress has been strongly pursued, the level of unemployment is about 3.6% in 2019, while in Italy it is equal to 9.2%. Therefore, technological progress might represent an opportunity for growth in the right context. A further interesting point is the model of networking[27] for the diffusion of innovation built in Asia against the European model not particularly inclined for networking. The capability to create virtual networks has empowered Asian countries, while in Europe there are two blocks: from one hand, Northern countries which benefit from the monetary union, from the other hand, Mediterranean and Eastern countries and to some extent France which have been severely hit by monetary union and fiscal rules. Asian win-win model of networking in the field of innovation, guided by Japan, helped each country to grow[28]. They are developing the employment of artificial intelligence in productive activities and their institutional behaviour appears orientated to exploit this new technological tool. Investing in human capital and R&D in the past and supporting the education and training of low-skilled workers, they will probably be better equipped than Italy to cope with artificial intelligence diffusion in production activities[29].

Against this background, we are going to illustrate some important features of the innovation environment built in Korea and Singapore. A huge literature deals with this field, highlighting the strategic role played in the early stages by the two governments in building a context open to innovation and capable of taking advantage of technological progress[30].

The genesis of the knowledge-based economy built in Korea started with a fast industrialisation based on labour-intensive exports, import of capital goods from advanced countries and investments in technology. The government invested significantly in the ICT industry, bringing about high-quality telecom infrastructures also thanks to the coordination among seventeen ministries for R&D. In addition, Korean government implemented essential reforms of the education and training system,

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[26]See for example: Edquist C. and Hommen L. (2008) Comparing national systems of innovation in Asia and Europe: theory and comparative framework, CIRCLE, Paper No. 10.

[27]Not meant to imply political cooperation.

[28]At the meeting of the Association of South-East Asian Nations (ASEAN) in October 1993, Japan, submitted a draft plan for technical assistance to Malaysia and Thailand. The plan aimed at fostering those total quality management systems which in Japan had successfully been developed (Litsareva, 2017). Similarly, in January 2010, the Asia Pacific Innovation Network was formed, to bring together scholars in the Asia Pacific region interested in the Legal, Managerial and Economic aspects of innovation.

[29]Harrison et al. (2014) found strong empirical evidence that innovation creates employment at firm level, especially thanks to the introduction of new products.

[30]Acharya, 2008; Haas, 1989; Youn and Hyeng, 1997; Amyx, 2004; Ando and Kimura, 2003; Giround, 2004; Henning, 2002; Thant, Tang and Kakazu, 1995; Lian, 2002.

among which the interaction between the tertiary education system and on-the-job-training. It was a general design aimed at improving human capital, which is essential for the knowledge-based economy. At the beginning, resources to be invested in technology and human capital were public, but then, from the 1980s onward, the private sector started to participate in supporting them. In addition, Korean policy maker provided incentives for R&D through fiscal and trade policies (as for example tax credits, accelerated depreciation and lower import tariffs). From the mid-1990s, Korean international competitiveness in high skill-intensive sectors has improved more and more (Asian Development Bank, 2014).

The genesis of the knowledge-based economy in Singapore followed a similar pattern. During the 60s and 70s the economic model of production was labour-intensive; however, in the 70s this model changed to be skill intensive. From the 80s onward, the production model changed again and became progressively capital intensive, technology-intensive and based on knowledge and innovation. This process towards a knowledge-based economy was driven by foreign direct investment (FDI) and supported by government; moreover, it was a way to import high technology and participate in the global value chain. Afterwards, Singapore started to rely on domestic R&D capabilities. As well as the Korean, Singaporean government invested in the promotion of ICT in every activity of society. Contemporarily, it invested in technical education and on the job training in multinational corporations, in order to raise the skill levels of Singaporean workforce. Singapore reached a high competitiveness especially in trading services. In 1990, the appointed Services Promotion Division in the Economic Development Board contributed to make Singapore the foremost Asian country in business and financial services (Asian Development Bank, 2014).

As far as education and training system is concerned, Korea and Singapore (as well as Taiwan Province of China and Malaysia) tried to establish a relationship with world leaders in the field of high technology (for example, United States, Germany, France, and the United Kingdom) and promoted local and global networks. As a consequence, national firms implemented strategic alliances with high innovative firms located in Asia or abroad. Both Singaporean and Korean governments carried out policies aimed at attracting national professionals studying or working abroad and foreign professionals through international exchange programs[31]. Indeed, in the Republic of Korea, in the mid-1970s, a special government program attracted a massive number of Korean specialists under training in top-rated American universities (Litsareva, 2017)[32]. They were employed in new ad hoc created research institutes such as the Korea Advanced Institute of Science and Technology and the Korea Institute of Science and Technology (Asian Development Bank, 2014)[33].

In other words, Singapore and Korea developed a knowledge-based economy with the following characteristics:

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[31]The Korean Education Development Project 2020-2030 aims at improving the quality of the education system; being acknowledged by the international scientific community trough cooperation between Korean and foreign universities; making education institutes more attractive for both Korean and foreign talent; increasing the number of educational institutions which provide lifelong learning. The Korean government allocated five billion for the Scholarship Fund of the Republic of Korea and planned to allocate up to 1.1% of GDP for the education reform (Litsareva, 2017).

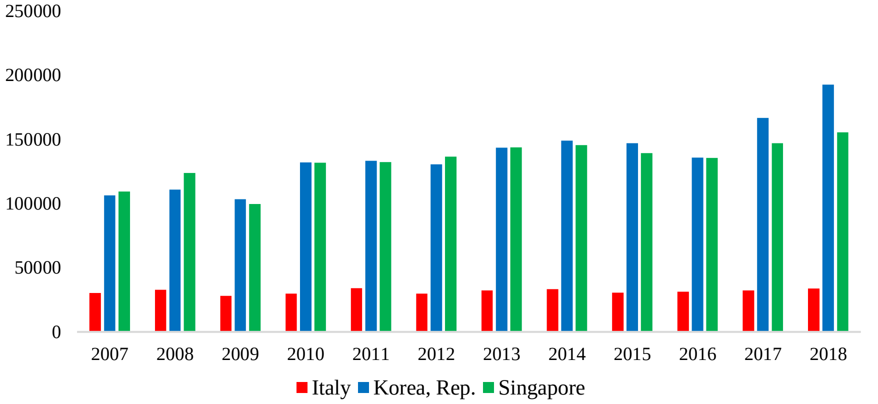
[32] For example, in 1976, the Electronics and Telecommunications Research Institute (ETRI) was created in the field of industrial R&D, a non-profit public institution financed by Government. The Institute has successfully developed information technologies in areas such as microchips, semiconductors, high-end computers, digital mobile communication systems, and high-speed data transmission (Litsareva, 2017).

[33]Asian Development Bank (2014), Innovative Asia: advancing the knowledge-based economy, Highlights of the forthcoming ADB study report, ADB. Available at: https://www.adb.org/sites/default/files/publication /41752/innovative-asia-knowledge-based-economy.pdf.

- Research institutes have a key and recognised role and are now funded by both the State and the private sector;
- Scientific world cooperates with the industrial world to foster innovation in productive activities;
- Great support for talented people and attraction of foreign talented people[34].

The pillar of the knowledge-based economy is knowledge, every policy, instrument or initiative build up to favour the acquisition and the diffusion of knowledge is important within this model.
Not surprisingly, Korea and Singapore export high-technology goods and services much more than Italy (Fig. 9)[35].

Fig. 9 - High-technology exports (current millions US$)

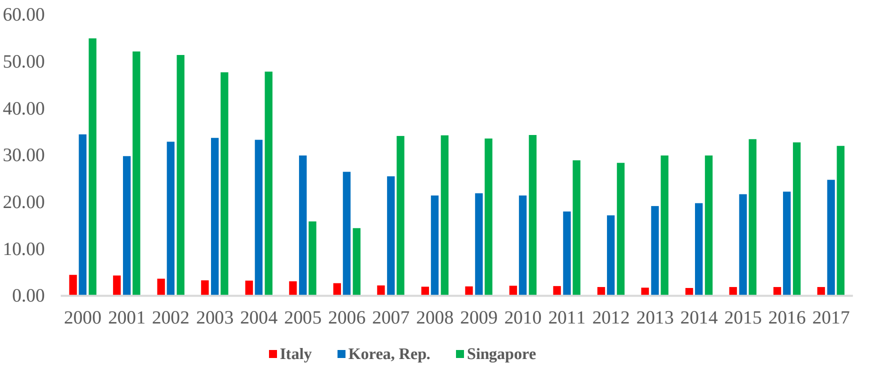


Source: World Bank data

The gap between Italy and the two Asian countries is even more evident considering ICT good exports as a percentage of total good exports (Fig. 10), even if the trend is diminishing for all the three countries. Probably the declining share of exports of ICT goods for Korea and Singapore is due to the increasing competition from other emerging countries, among which China[36].

[34]Litsareva E. (2017), Success Factors of Asia-Pacific Fast-Developing Regions' Technological Innovation Development and Economic Growth, International Journal of Innovation Studies 1(1), 72–88.
[35]Data are available at: https://data.worldbank.org/indicator/TX.VAL.TECH.CD?locations=IT-KR-SG&name _ desc=false&view=chart.

[36]Tham Siew Yean (2016) (a cura di), *Moving the AEC Beyond 2015: Managing Domestic Consensus for Community-Building*, ISEAS publishing.



Source: World Bank data

Nevertheless, the point we want to highlight here is that Italy has not invested in innovation, as shown also by its high-technology exports.
As far as innovation is concerned, Italy shows the following general shortcoming:

1. Italy does not belong to a cooperative area. In Europe some countries implement innovation policies and are technologically advanced, but they rarely promote - as Asian countries do - innovation networks. Moreover, fiscal policies aimed at reducing public debt limit further the possibility to invest in innovation.
2. The long-term disinvestment in the education and training system and in R&D is also the result of a domestic poor institutional context and public choices (Tab. 3).

A huge literature highlights the reasons of Italian innovation gaps[37]. According to Moncada-Paternò-Castello P. and Grassano N. (2014), *innovation in firms without their engagement in R&D activities is not sustainable in the medium and long term; moreover policy interventions will have little positive impact without comprehensive reform aimed at improving the innovation environment as a whole*. In other words, innovative firms may find difficult to operate in an obsolete context, where, for example, the Public Administration is scarcely digisalised and made inefficient by corruption, red tape and rent-seeking. Indeed, during the last five years several incentives for R&D have been provided to firms but their profitability for firms remains low [38]. The structure of Italian firms calls for a specific policy mix, aiming at increasing R&D investments by firms not yet engaged in them and supporting the efforts of firms investing in R&D.
Istat (2019)[39] provides interesting insights on the competitiveness of Italian production system. According to the "Report on the competitiveness of industries" (Istat, 2019) tax incentives (namely the reduction of the capital income tax) have benefitted companies which have already shown a good investment performance in 2018, since the access to the financial credit is more favourable. In addition, it underlines that the production system is characterised predominantly by small firms with a low propensity to innovate and dependent from the domestic market. Finally, it highlights that Italian productive system is not able to create a "network" among firms in order to favour the transmission of international positive cycles, technological spillover and productivity increases (network analysis). In other words, the Italian productive system shows a low propensity to

[37]See for example: Moncada-Paternò-Castello P. and Grassano N. (2014), Innovation, competitiveness and growth without R&D? Analysis of corporate R&D investment - A country approach: Italy, JRC Policy Brief, European Commission, November.
[38]OECD (2019), R&D Tax incentives: Italy 2019, OECD. Available at: https://www.oecd.org/sti/rd-tax-stats-italy.pdf.
[39]ISTAT (2019), Rapporto sulla competitività dei settori produttivi, Edizione 2019, Istat.

innovation. Given the structure of globalised markets, the long-term unemployment in Italy is structural and depends upon specific contextual variables. A new technological revolution spreading artificial intelligence in the Italian labour market could be enormously dangerous if new policies aiming at reinforcing the overall capacity to take advantage of innovation are not put in place.
As we have discussed in Section 4, the quality of Institutions is a crucial gap of Italian context (Tab. 3), namely government effectiveness and rule of law. However, a further important shortcoming, not always discussed, is the absence of a meritocratic system. Ruberto (2015) underlines that a society based on the power of privileged groups and lobbies may not show a high propensity for innovation. Firms' perception that using undeserved business advantages, obtained colluding with corrupted politicians, is the only way to do business in Italy, is a great disincentive to innovate.
To enable collaborative innovation, policy maker should not only provide the right legal and regulatory framework and develop the necessary infrastructure, but also promote "trust" among firms and between firms and government (Msanjila, S. and Afsarmanesh, H., 2008).

Conclusion

From a methodological point of view complex issues may be better dealt with using comparative analysis, since it is difficult to find the right measures and indicators of a complex phenomenon and it is quite difficult to transform it in mathematical functions. Whether artificial intelligence may result in massive unemployment or not requires a deep observation of past and recent trends of technological impacts as well as the institutional characteristics of the countries involved. Ongoing investigation is essential to understand complex issues; however, it is possible to acquire some results at every stage of the investigation.
Data described in this paper suggest two preliminary findings. First, the impact of technology (for example artificial intelligence) on employment may differ according to the specificities of every context as well as the nature of the technology involved. Countries investing in human capital and with a high propensity to innovation seem less hampered by technological advancements even in the short run. Second, the quality of institutions, namely government effectiveness, rule of law, meritocracy, political and operational stability, is crucial to cope with a technological revolution and make it a great opportunity for growth.

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