Introduction

Nearly 90 years ago John Maynard Keynes published a short and visionary article where he tried to imagine economic life in two generations. He envisaged a sharp decline of labour demand due to technological substitution that he called “technological unemployment”:

We are being afflicted with a new disease of which some readers may not yet have heard the name, but of which they will hear a great deal in the years to come – namely, technological unemployment. This means unemployment due to our discovery of means of economising the use of labour outrunning the pace at which we can find new uses for labour.

(Keynes 1930: 360, emphasis in original)

Technological unemployment is indeed an unavoidable and ubiquitous consequence of technological change based on the introduction of new capital goods. At the outset of the first Industrial Revolution Luddites destroyed textile machinery because it was stealing their jobs and wages. Indeed, we can now say that Luddites were right in the short run but utterly wrong in the long run. The machines which the first Industrial Revolution was based on did destroy jobs of the workers they replaced, but they hugely increased the productivity of labour and increased its value and remuneration and, especially, lots of new jobs were created by the new organisation of production. Machines had to be produced by the rising machine sector. The factory system was “delegating” many simple routine production tasks to machines but also creating opportunities for new less simple and routine tasks. For instance, the factory system was a complex organisation which required coordination jobs which simply did not exist before. The internal division of labour needed coordination, the factory had to work on a continuous basis.
and input and output markets had to be constantly monitored and secured in order to avoid disruptions, financial management also became far more complex. It was the birth of the industrial and service sectors’ white collar class.

Today we are entering the fourth Industrial Revolution,1 accompanied by a new wave of substitution between labour and capital and we can even encounter new forms of Luddism (Jones 2006). Can we expect that, like the previous Industrial Revolutions, job losses will only characterise a temporary short run phase and that new jobs will be finally created in a number at least equal to those that will be lost? And that the new jobs will be, on the whole, of better quality than the lost ones – less routine, more interesting, more creative, more productive and therefore better paid?

An “optimistic” vision tends to answer yes to such questions, claiming that roughly the same virtuous adjustments that took place in the previous Industrial Revolutions will operate also in the present one. Such an adjustment may be painful and require one or more generational turnovers and profound institutional changes in the education system and labour markets, but it will finally happen. According to this view, technological unemployment is a temporary frictional phenomenon, and governments, trade unions and other institutions, especially those devoted to education, should operate to facilitate such transition and to help make it socially acceptable by providing support to the “losers” of the transition.

But an opposite view claims that this time it is different. The fourth Industrial Revolution has some common characteristics with the previous ones, but also some important peculiarities that make its nature and in particular its long-term impact on the labour market different from what we observed in the past revolutions. In particular, past mechanisations could only substitute routine manual work, while today’s automation is likely to concern jobs which involve more and more sophisticated cognitive skills and even learning. According to this view, digital technologies, AI, machine learning, big data, internet of things have some important features which will mark a sharp discontinuity with previous Industrial Revolutions. Persistent technological unemployment and growing inequality will characterise a long historical phase and the consequences on the organisation of production and society will go well beyond frictional adjustments.

Keynes himself in his 1930 essay gave a fundamentally optimistic view and considered technological unemployment as “a temporary phase of maladjustment”. If we are going towards a world in which production requires little labour, then “[a]ll this means in the long run that mankind is solving its economic problem” (ibid., emphasis in original). However, his optimism was founded on a rather radical change in the organisation of society (i.e. massive reduction of working hours per week and massive redistribution programs) funded by high taxes on capital income.

In this short note I will briefly review the main arguments of the two visions. Personally, I am more convinced by those put forward by the “pessimistic” view, mainly because I think that the underlying “microeconomic” features of the new technologies are profoundly different from those of the previous Industrial Revolutions. I will argue that some of virtuous circles which have been activated in the past are unlikely to operate this time. Needless to say, I am absolutely aware that long-term forecasts should always be taken cautiously and that reality often surprises us. New kinds of virtuous circles may well arise in the future that we do not envisage.

1 The fourth Industrial Revolution is based upon robotics, artificial intelligence, big data, internet of things, biotech, nanotech (Schwab 2016). Some authors consider it as a development of the third Industrial Revolution (based on computers and internet) rather than a new one. Regardless how we label it, it is a wave of technological change which is just beginning, and we can hardly imagine the precise directions it will take.
today. Thus, my position is that yes, this time is different and we are going to face some serious societal challenges caused by the new technologies, but of course we do not know what the long-term consequences will be.

**Automation and codification**

Let me begin with an extremely sketchy and somehow rough view of the first Industrial Revolution. It was essentially based upon two interrelated processes: codification of knowledge and division of labour. The former was part of a long-lasting effort to have a “scientific” approach to productive knowledge. Formerly tacit knowledge, embedded in the minds, hands and actions of artisans was codified, reported in textual records, analysed and taught. This process of codification and understanding also allowed a parallel process of decomposition of such knowledge into simpler sub-tasks. This division of labour allowed specialisation, the use of a less qualified workforce and vast opportunities for the development of capital goods which could perform some of these extremely simple routine tasks with higher strength, continuity, reliability and efficiency than human workers.

This process of codification of tacit knowledge was and is still today pushed by strong economic forces. Tacit knowledge suffers in fact from dramatic organisational inefficiencies. Tacit knowledge can be apprehended only by a long and painstaking period of practice which consists of working side by side with someone who possesses this knowledge. This was reflected in the masters-journeymen-apprentices organisation of work typical of pre-industrial guilds. Codified and divided productive knowledge consists instead either of simple tasks that can be learned very quickly (those of the shop floor worker) or of highly specialised codified tasks that are learned in the formal training of engineers, chemists and other highly qualified technicians. However, typically, the latter training is mainly paid not by firms but by society as a whole and/or by the trainee.

Codification was a precondition for automation: machines can only perform perfectly codified tasks, and when machines could be introduced, they quickly outperformed human workers and made them redundant. In this sense Luddites were right. But this was not the end of the story, since many compensating factors counterbalanced the reduction of work per unit product. Just to summarise the main ones, lots of new jobs were created in the machine-producing sectors, in activities different from mere shop floor jobs (clerical, management and all sorts of “coordinating” tasks), and because of the general decrease of prices and increase of quantities thanks to technological change, innovation itself fuelled economic growth and increase of income (see, e.g., Piva and Vivarelli 2017 for a critical survey).

The overall outcome was an increase of employment, wages, and also of “quality” of work, though the process also involved a lot of social suffering and unrest and major societal and institutional changes.

Today, the technologies of the third and fourth Industrial Revolution are pushing the codification of knowledge to unprecedented levels. Such technologies are nothing else than codification technologies, as they are based upon digitisation, that is the translation of any kind of information and knowledge into a digital code that can be understood and automatically processed by a computer. In addition, the new “machines” are not bound to executing simple, repetitive, physical tasks, but they are more and more capable of performing highly sophisticated and complex procedures, involving change, adaptation, cognition and even learning. Are the same “virtuous” compensation mechanisms going to operate also for these new technologies or not? In the next two paragraphs I will briefly review the main arguments for a “yes” or “no” answer.
The optimistic view

The “optimistic” view acknowledges that new technologies will cause the loss of many jobs but foresees that in the long run compensation effects will occur, new jobs will be created and the labour markets will adjust. Some of these compensation effects will be very similar to those that have been operating in the previous Industrial Revolutions: new jobs will be created in the machine-producing industries, in human tasks which complement such machines, and in all sectors which, though experiencing a decrease of the labour input per unit product, will benefit from a considerable growth of demand due to the decreasing prices and higher efficiency enabled by automation itself.

Other compensation effects will instead be specific to the fourth Industrial Revolution. Many analysts envisage in the next decades a shift of demand from manufacturing goods to services in which the human component is central and cannot be substituted: healthcare, personal care, relational goods, creative goods, etc.

Of course, also the optimistic view acknowledges that compensation effects will take time, important changes in the educational institutions and in the labour markets and, not least, in the very mentality and culture of people. A few generational turnovers may be needed before the adaptation is completed and in the meantime, technological unemployment can considerably rise and create social unrest. New jobs will be very different from the old ones and they will require new competences that the dismissed workers will probably lack. Public policies will play a key role by both providing some safety net to the victims of the new technologies and by promoting the necessary institutional changes. As to the former, various measures can be envisaged from unemployment benefits to forms of basic income and other poverty reduction measures. As to the latter, public policies should promote a quick and smooth transition. On one side, industrial policies should favour the adoption of new technologies; on the other side, they should promote the necessary changes in the education system and in the labour markets. The education system plays a particularly central role: Goldin and Katz (2008) provide a formidable account of the interaction between education and technology and show that the supply of highly qualified workers with the right qualifications is key in boosting income growth and equality of its distribution.

The pessimistic view

The pessimistic view claims that that the fourth Industrial Revolution has some important features which cast serious doubts on the predictions that also this time compensation effects will be able to initiate and feed the virtuous circles we observed in the past. Such novel features have to do with the nature of the technologies at the core of the fourth Industrial Revolution but also with the socio-economic transformations that are accompanying the current wave of technological change.

The starting point is the observation that digital technologies are pushing the process of codification of the human know-how to an unprecedented level. The new technologies are nothing else than codification technologies: they codify more and more complex tasks, and with artificial intelligence they even promise to codify complex cognitive task and learning. In the previous Industrial Revolutions machines were only able to perform simple repetitive tasks. Their advantage over human workers was limited to a higher force, higher precision and lower exposure to fatigue and boredom. But whenever information processing, flexibility, adaptation, learning, creativity, etc. were involved, machines had no chance to substitute humans, but at most to complement them.
Computer-based technologies on the contrary far exceed human capabilities in information processing and are almost inevitably going to substitute humans in all the tasks based on information processing, regardless of their complexity. Technology scholars were citing only a couple of decades ago such tasks as driving a car as a typical task that could never be automatised. They were saying that driving a car involves lots of tacit knowledge and learning by doing (it is in fact a task that we learn through practice), in which a broad repertoire of simple tasks, such as braking, pressing the clutch, changing gear, etc. must be combined in a specific and often novel way to cope with a potentially infinite set of situations whose detection requires the processing of a big amount of sensory data. Indeed, it was said, some of the simple tasks (such as gear changing) could be automatised, but not their creative, complex and heavily information-dependent combinations. Today self-driving cars are real and will presumably become a dominant technology quite soon. Interestingly they do not mimic human tacit knowledge but exploit the huge computational and information processing power of modern computers and algorithms.

The increase of information processing power and the advancement in learning algorithms are likely to generate a wave of technological innovations which will expand the domain of machines to non-routine, complex and cognitive tasks. Algorithms can now take complex decisions in financial markets, diagnose illnesses, make intelligent searches of legal databases, all tasks which were before performed by highly qualified workers with college degrees. Far from being relegated to shop floor tasks, machines are substituting clerical and even professional specialist labour.

Beaudry et al. (2013) find a “great reversal” occurring since the beginning of the new millennium: the demand for highly qualified cognitive jobs in the US is declining, while US universities keep increasing the number of graduates. The outcome is the increase of unemployment and underemployment and the decrease of wages for many categories of college graduates.

Frey and Osborne (2017) have considered 702 jobs and estimated their probability to be taken over by computers. They conclude that most of the jobs in the manufacturing and in clerical work will disappear, while those which have the lower risk of disappearing are those which involve human interaction, such as most of the jobs in health and education, political and managerial skills or highly specialised technical and scientific competencies. Filippi and Trento (2019) have recently carried out a similar inquiry on the Italian case and found also a relevant, though weaker, impact of the new technologies.

But in addition to this standard labour substitution argument, new technologies may have a negative impact on employment for some additional and less obvious reasons, which I will discuss in the next section.

Employment and productivity in automation technologies

As already mentioned, one of the fundamental compensation effects in an Industrial Revolution is the creation of new jobs in the industries which produce the capital goods which are at the core of the new technologies. In the first and second Industrial Revolution a considerable amount of jobs were created in the industries producing engines, electricity, steel, machine tools, etc. The third and fourth Industrial Revolutions are based on computers and digital goods – software and any other kind of file which can be processed by a computer. Although by far not the only constituent element, digital technologies and digital goods are at the core of the third and fourth Industrial Revolution, as the steam engine, steel and electricity were at the core of the first two Industrial Revolutions. The production technologies for digital goods such as software and any other kind of files which can be processed by a computer are quite different from the production of standard manufacturing goods and services. Once the first unit of a digital good has
been produced, duplicating it has almost zero cost (Quah 2003). Thus, the costs of production are essentially fixed costs whereas marginal costs are negligible and the labour input goes almost entirely into the production of the first unit. This cost structure has some important consequences (Guellec and Paunov 2017). First, the link between quantity produced and employment is rather weak as quantity can be increased with little labour input. This compensation effect was due to the increase of production which was perhaps the most important virtuous circle operating in the previous Industrial Revolutions: the labour input per unit product decreased but output increased much faster, producing a positive net effect on employment. In digital technologies instead, the effect on employment of increasing output tends to be limited.

Second, this cost structure with almost zero marginal costs resembles one of natural monopolies and leads therefore naturally to high concentration, especially in the presence of network economies that often characterise digital technologies.

A second important phenomenon is the impact that internet and digital technologies have on the production services. It is well known that production of services was normally subject to a major source of inefficiency as they required contemporaneity and co-presence of production and consumption. If today I want to buy a car in Rome I can buy one which was produced weeks ago in a factory located thousands of miles away. If instead I need a medical service, the physician must have spare production capacity here and now and devote it specifically to me. This makes the production of services highly inefficient because it can serve only a small local market, cannot exploit economies of scale and cannot produce or buffer inventories. But, on the other hand, services have been a source of employment, often of high quality, which was inevitably much more geographically diffused then employment in manufacturing, which tends to be much more concentrated. Information technologies and in perspective AI are partly delinking production and consumption in many services: with internet banking, we can operate with a branch of our bank located on the other side of the earth, or simply located in the “cyberspace”. The potential for a massive process of “industrialisation” in the production services with economies of scale and agglomeration, creation of large production units serving the large markets and opportunities for division of labour and specialisation is there in many other service sectors: from distribution to financial, medical and educational services.

Third, it is well known and largely debated that the current wave of technological innovation is not paralleled by a general increase of labour productivity. There are many possible explanations of this apparent paradox (Brynjolfsson 1993; Gordon 2000; Acemoglu et al. 2014) but one of them suggests that an important part of the current wave of innovation is not enhancing the productivity of workers but simply substituting them even in tasks in which machines are not performing much better than humans. Moreover, also the technology-driven creation of new jobs is disappointing:

if all we do is continue down the path of automation, with no counterbalancing innovations to generate new tasks, the implications for labour are depressing. It will not be the end of work anytime soon, but the trend towards lower labour share and anaemic growth in labour demand will continue – with potentially disastrous consequences for income inequality and social cohesion.

(Acemoglu and Restrepo 2019: 5)

Conclusion: automation and inequality

I argued in this short note that the age of technological unemployment that Keynes envisaged 90 years ago might be approaching, though much later than Keynes foresaw. The fourth
Industrial Revolution is at our doorstep and promises to change radically the organisation of production and the role of labour. There is little doubt that many jobs will become obsolete and technological unemployment will rise. The long-term issue is whether this unemployment will be absorbed by a parallel creation of new and mostly better jobs. It is hard to give a precise answer to such a question, but I argued that some features of the new technologies and the new organisational forms of production cast serious doubts on the possibility that also this time the virtuous circles that in the past produced a positive long-run effect on labour will also operate in the next decades.

In the meantime, we are already observing clear signs of a general decrease of the labour share (Karabarbounis and Neiman 2014) and increase of job polarisation (Autor et al. 2006). These two phenomena are among the leading causes of the general increase of income inequality we have been experiencing in the last decades in all Western advanced economies (Piketty 2013; Milanovic 2016). Roughly stable for a long time, the share of the produced value which goes to labour has been declining since the 1980s to the advantage of the share which goes to capital. This is a clear sign of a macro phenomenon of substitution of labour with capital. On the other hand, the labour markets in the advanced economies are becoming more and more polarised, in the sense that we observe a sharp decline of employment in the “middle” range of skills and wages, while employment is stable or increasing at the extremes (i.e. for high skill and generously paid jobs on one side and for low skill and low pay jobs on the other). The former are jobs requiring very high qualifications, often linked to the creation, design and management of the new technologies. The latter are on the contrary jobs with very low qualification but in which the human component cannot be substituted or is so cheap that substitution is not economically viable. Migrations from poorer countries are often an additional factor that keeps wages for these jobs particularly low.

Last but not least, globalisation is accelerating many of the phenomena described. The few remaining labour-intensive tasks in production are often relocated in developing countries where wages and labour regulations allow major savings in labour costs. The global extensions of digital markets generate global monopolies that we could hardly observe in the past. The industrialisation of services is also accompanied by a relocation of production and jobs on the global market. Finally, migrations have, on one hand, created a kind of global elite of workers with top qualifications and offering labour on a global market and, on the other hand, of the spectrum, a global proletariat which exerts downward pressure on wages for the low-skill jobs.

References


