Whither the evolution of the contemporary social fabric? New technologies and old socio-economic trends[1]

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Abstract

The reflections which follow build on two interrelated questions, namely, first, whether we are witnessing another "industrial revolution", and second, what is the impact of technological transformations upon the current dynamics of the socio-economic fabric, especially with respect to employment, income distribution, working conditions and labour relations. We argue that the processes of innovation and diffusion of what we could call "intelligent automation" are likely to change the incumbent patterns of distribution of income and power, which have been there well before the arrival of the technologies we are concerned about. Some of them are indeed intrinsic features of capitalism since its inception, while others emerged over the last thirty-forty years. First, we shall offer a fresco of such tendencies which certainly preceded any potential "Fourth Industrial Revolution" but are going to be amplified by the latter, within a process that we shall call "rentification of capitalism". Second, we discuss the features of such possible new techno-economic paradigm, distinguishing between so-called Industry 4.0 and the more pervasive impact of big-data analytics upon the social reproduction sphere. Third, we examine the relationships between technology, productivity and growth, and the ensuing impact on jobs. Finally, we discuss the patterns of division of labour, distribution of knowledge, power, and control in the era of rentified capitalism. Finally, we address some policy implications.

The first man who, having enclosed a piece of ground, bethought himself of saying "This is mine", and found people simple enough to believe him, was the real founder of civil society.
[Discourse on the Origin and Basis of Inequality Among Men, 1754, J. J. Rousseau]

I. Introduction

The reflections which follow build on two interrelated questions which have been of great concern to us as well as to many other observers of contemporary socio-economic transformations,[2] namely, first, whether we are witnessing another "industrial revolution", and second, what is the impact of technological transformations upon the current dynamics of the socio-economic fabric, especially with respect to employment, income distribution, working conditions and labour relations. Of course, an easy reductionist approach would be to resort to the usual economists' repertoire: a production

1 Acknowledgements: The authors wish to thank the editor of the special issue and three anonymous referees which help us in improving upon the previous version. We gratefully acknowledge the support by the European Union Horizon 2020 Research and Innovation programme under grant agreement No. 822781 – GROWINPRO.

2 For a complementary discussions see, among the others, Franzini and Pianta (2015); Milanovic (2016).

This article has been accepted for publication and undergone full peer review but has not been through the copyediting, typesetting, pagination and proofreading process, which may lead to differences between this version and the Version of Record. Please cite this article as doi: 10.1111/ilr.12145.

function, some proxies for changing skills, supplies and demands for labour, and the answer is readily served: in the long-run the system will self-adjust to a new equilibrium path, with all unemployment being just frictional or voluntary, higher wages for those who undertake tasks required by the new technologies, and lower ones for those workers whose tasks are substitutable by machines. In fact, latter are somewhat responsible for inadequacy to what the market is asking, ought to retrain.

The route we chose to explore here is quite different, back to the basics, addressing the coupled dynamics between technological change and socio-economic evolution. In this respect, in this work we intertwine different levels of analysis. First, before assessing the impact of *new* technologies one should evaluate the pre-existing trends in income distributions, labour relations, and industrial structures. Second, the nature and the impact of technologies, old and new, ought to be assessed in their own right, well before plugging them into some, more or less far-fetched, history-invariant economic model. Third, the new and old technologies are nested in complex political economies, at all levels of analysis, ranging from the division of labour and power at firm level all the way to the policies concerning law-making, taxation, and demand-management. Fourth, whatever impact of technological and institutional changes ought to be assessed well beyond per-capita GDP growth rates. For example, welfare and working conditions, equality in opportunities, social mobility and quality of life are at least equally, if not more, important. In our view, we are currently facing a major historical bifurcation whereby the future long term patterns are going to be shaped by the present socio-economic structure, the power relations and policies.

Arguably, never since the First Industrial Revolution the competition between man and machine and the ensuing working conditions have been starker, especially when coupled with the explosion of rent-seeking behaviour and the risk of social exclusion as in today's globalised and financialised economy. What can we learn from the past? Historians are quick to point out that such concerns are not unique to this age, but have characterised all industrial revolutions, during which the relationship between machines and human labour saw dramatic developments. On the one hand, new technologies threaten established ways of doing things, working conditions, employment patterns; on the other hand, they provide new opportunities for economic growth and social change. So much so that in the long run, technology has proved a formidable engine of growth and has enabled very significant improvements in living conditions. Emergent technologies can provide new business opportunities and enable effective solutions in areas of application which existing technologies are not able to cope with. So for example, activities such as medical services and health care, where costs are increasing rapidly and disproportionately, can derive enormous advantages from the adoption of new technologies, provided those in need have adequate access to them.

Similarly, at macroeconomic and societal levels, paraphrasing Chris Freeman, new technologies may herald an "economics of hope", with work for all and equitable social inclusion, or conversely, mass unemployment, mass inequality and social exclusion, leading to a "re-feudalization" of Western societies (Freeman 1992; Freeman and Soete 1994). In all that, technologies are not good or bad as such: rather, in the emergence and the early selection of the new dominant paradigms, social and economic factors are crucial.

Nowadays, we are still in a position to collectively "choose" where one is heading in terms of constellation of paradigms,[3] in one of the rare historical window of opportunity. In this respect, we can think of two extreme archetypes. The first one, call it the "Blade Runner" scenario:[4] a sort of techno-feudalism, extremely sophisticated in its small ruling class, with a vast majority of *lumpenproletariat,* including a very intelligent, but largely obedient population, enforcing power and income distribution in favour of the rich and powerful. Indeed, one drawback of the film is that it does not emphasize an even more extreme scenario: a class of ignorant and greedy rentiers sharing power and wealth with the techno-feudal class, and the *lumpenproletariat* basically made up of almost sub-human slaves without citizenship or rights.

At the opposite extreme there is a range of alternatives going from progressive and liberal proposals a' la Keynes (1930), still within the scope of the capitalist society, to the Communist Manifesto advocating the entire reorganization of societies, based on the Marxian utopia "from each one according to his ability, to each one according to his needs". Under this archetype, new technologies will free mankind from boring, degrading, alienating works and we shall all be able to spare most of our time for leisure, playing, satisfying curiosity, learning, enjoying life. Nowadays indeed we are in the position to consider it as a *workable utopia*, at least in developed economies.[5]

Come as it may, the processes of innovation and diffusion of what we could call "intelligent automation" are likely to change, and most likely reinforce, the uneven patterns of distribution of income and power which have been there well before the arrival of the technologies we are concerned about,- some indeed intrinsic features of capitalism since its inception, others specific to the last thirty-forty years. On the technological side, there are both elements of paradigmatic discontinuity together with more incremental change: what is new about the current technological transformations is the "intelligent" use of Big-data to execute control over the social sphere, while there does not seem to be a comparable paradigm-shift in terms of the usage of I4.0 technology/devices vis-a'-vis the previous ICT-based automation of production (Moro et al., 2019).

In Section 2, relying on a vast ensemble of secondary evidence, we shall offer a fresco of some tendencies which certainly preceded any potential "Fourth Industrial Revolution" but are going to be amplified by the latter, putting forward the notion of "rentification of capitalism". In Section 3, we discuss the features of a possible new techno-economic paradigm, by distinguishing between Industry 4.0 and the more pervasive impact of big-data analytics upon the social reproduction sphere. In Section 4, we examine the relationships between technology, productivity and growth, while the ensuing impact on jobs are discussed in Section 5. Section 6 looks at the patterns of division of labour, distribution of

[3] *Techno-economic paradigms* consist in a constellation of micro-technological paradigms in the sense of Dosi (1982) (e.g. semiconductors, electronic computing, etc..) with a pervasive impact on the all economy in the sense of Freeman and Perez, 1988. Indeed, we abstain from any precise periodization as Perez does.

[4] From the science-fiction film *Blade Runner*, 1982, by Ridley Scott.

[5] For developing economies this is still far-away: a lot of technological and organizational learning, together with demographic control, lies ahead: however, qualitatively, the alternative between the two archetypes applies at all levels of development.

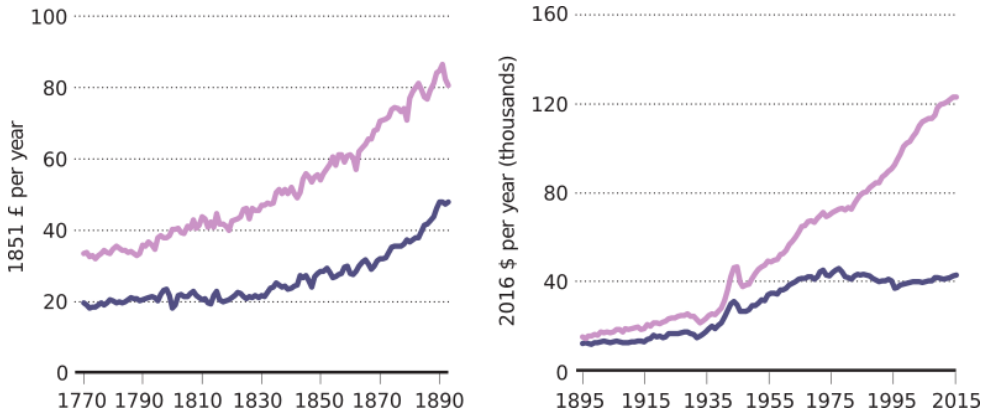
knowledge, power, and control in the era of rentified capitalism. Finally, Section 7 addresses some policy implications.

II. Some broad trends

It is broadly understood that economic growth takes place quite unevenly. This applies across countries and also across social groups and classes within countries. The Industrial Revolution has been possibly the biggest episode in human history entailing such an explosion of divergences, even greater than the bifurcation of agricultural societies from hunter-gatherers one, a few thousand years ago (Dosi, Freeman, and Fabiani 1994, Freeman, 2019). Our primary concern here is however what happens with industrial societies characterised since their take off by persistent technological change leading to exponential growth in labour productivity. In this respect a crucial issue regards the relationship between productivity and wage dynamics.

In aggregate terms, such relationship between productivity gains arising from new technology and wage growth has been punctuated by alternate phases. During the First Industrial Revolution (1770-1830) wages almost stagnated and started to rise only from 1830, approximately sixty years after the initial take off in output per worker, what Allen (2009) calls the *Engel pause* (left panel of Figure 1). At the same time, a whole sub-continent, India, was forced to an "early deindustrialization" and massive starvation. A much tighter link between productivity and wage growth characterised the "Western ascent to affluence" (1830-1970), according to the periodisation proposed by Allen (2017). However, a new phase of decoupling started in the seventies and has continued ever since – Allen calls it the "problem-ridden present" (right panel in Figure 1).

Figure 1: Wages in Britain 1770-1893 (left panel): the Engel pause
Wages in the United States1895-2015 (right-panel): the long term wage-productivity gap. Pink line: GDP per worker, purple line: wages.



Source: Allen (2017), p.2.

In fact, such an expression might be a euphemism to mean *capitalism back to normal*, after the Glorious decades post-WWII, whereby, together, near full-employment, trade union organizations, social conflict and the scare of the Soviet Union led to relatively fair deals in the labour markets and in labour relations, as well as to highly redistributive fiscal regimes. Recall that President Eisenhower's taxation scheme in the 50's included an average tax on profits around 60% and the marginal rate on personal income at around 92%. And that was the period of highest US growth and highest investment rates over the whole US history.

All this is with regard to the long-term patterns.[6] Conversely, in the shorter run other phenomena – to repeat, relatively independent from major technological changes – have deeply affected income distribution, labour relations and working conditions. Let us briefly consider a few of them.

Trend 1: Globalisation and the emergence of China as the world factory economy

After forty years of promotion of free trade, the liberalization of capital movements clearly turned out to be one of the main drivers of instability and precursor of financial and economic crises (Stiglitz 2002). On the real side, the global distribution of value chain has resulted into an international division of labour favouring some high skilled workers and capital owners in both developed countries (with a losing middle class) and developing ones (with manufacturing workers massively exploited), exacerbating inequalities and social divide. A large fraction of value creation of international products and services is still done in the establishments located in developed countries, while what has been delocalized tend to be the low value added phases of the production process (Timmer et al. 2014; Trade Development Report 2018). However, the most striking phenomenon has been the emergence of China as the world factory economy, which in few decades, with a spectacular growth, became the largest manufacturing producer and the largest economy of the world, catching up in *all phases of the value chain* and in most production activities, from low to high tech ones. But with that came also a massive change in the international distribution of working conditions (see also below).

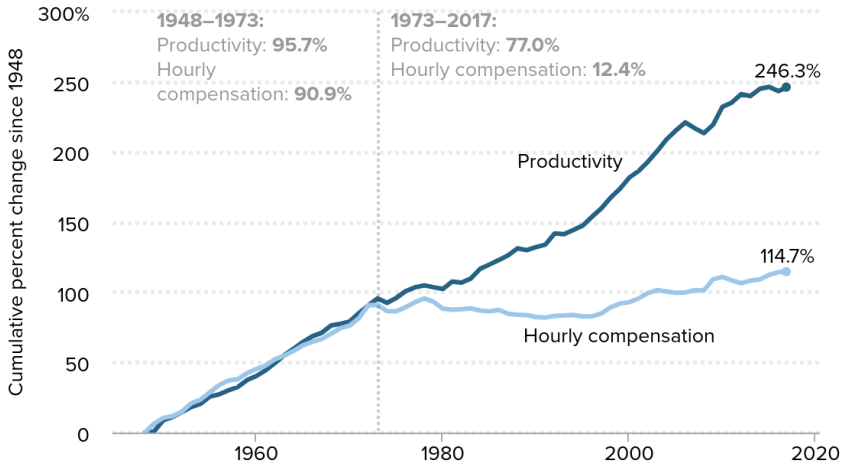
Trend 2: Stagnant wages and divergence between productivity growth and wage growth

If the Golden Age of capitalism was characterized by a balanced wage/productivity growth, and a constant wage share in GDP, since the eighties the wage-productivity nexus has weakened, with a declining pass-through from the latter to the former (Figure 2).[7] The decoupling of the two elements is highlighted by two concurrent factors: a declining labour share (Figure 3) and an increasing divergence between median and mean wage income (Schwellnus, Kappeler, and Pionnier 2017; Hutchinson and Persyn 2012; Karabarbounis and Neiman 2013).

Figure 2: The wage-productivity gap in the U.S., 1948-2014

6 In the following we shall primarily use statistical evidence from the U.S. as most complete one. However, the qualitative patterns are similar all over most of the OECD countries.

7 Note that the apparent scaling difference between the right-hand side of Figure 1 (long term trends) and Figure 2 (post WWII trends) is due to the fact that the former regards wages per worker while the latter regards wages per hours.



Source: Bivens and Mishel (2015)

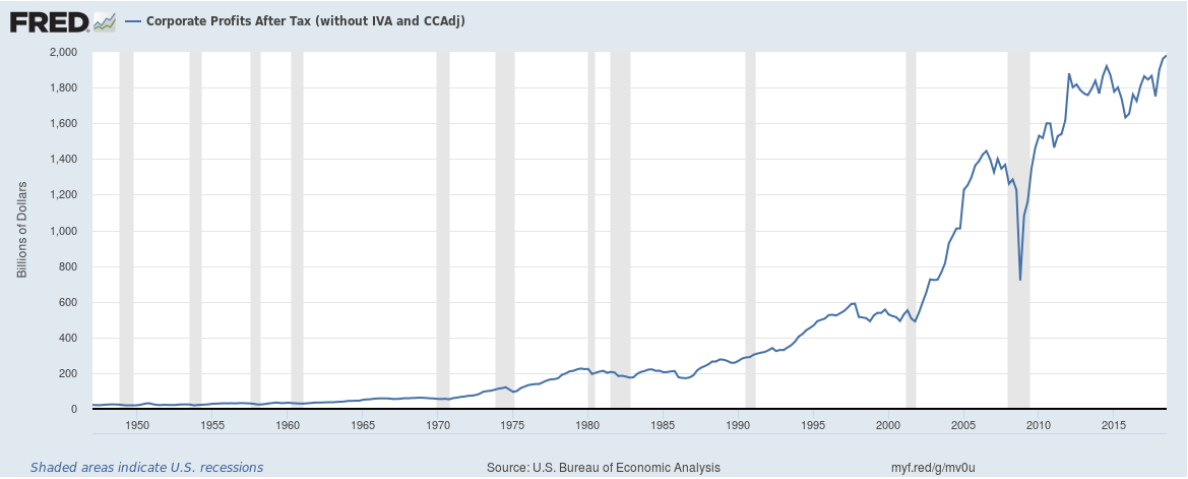
Figure 3: Declining labour share. Source FRED DATA SET

INSERT FIGURE 3 (from the pdf file attached)

Trend 3: A surge in corporate profits and top level incomes

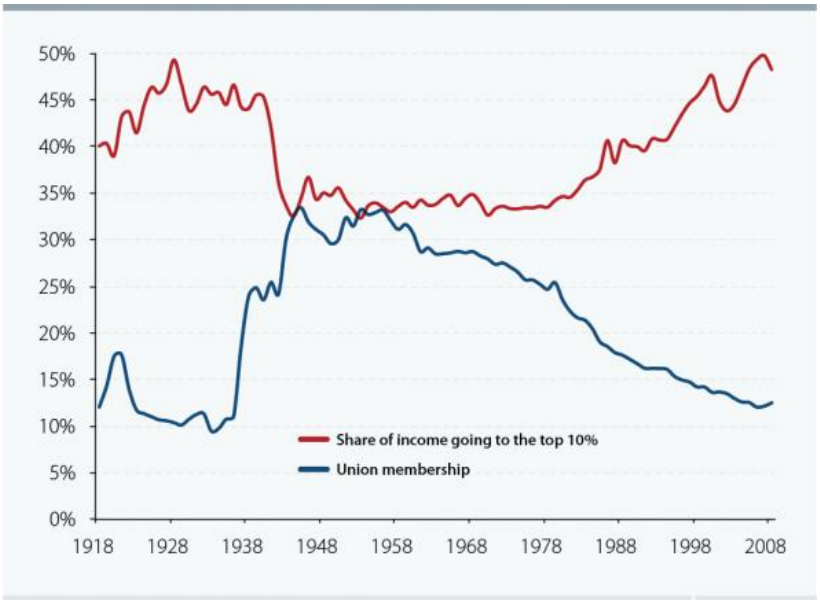
Profits and top incomes have been the only components of GDP which underwent huge increases in the last decades: most likely this is the result of weaker labour bargaining power and the deterioration of labour market institutions. Moreover, corporate profits have been extremely resilient to the Great Recession, with just a temporary decline, immediately largely rebalanced by massive growth (Dabla-Norris et al. 2015) (Figure 4). Even the IMF (Jaumotte and Buitron 2015) points at the transformation of labour market institutions as the source of both functional and personal income inequalities. In all that, extremely relevant are the declining unionization rates, as unions have always played an import role in promoting a relative egalitarian income distribution both at the aggregate level (Figure 5), and at the level of the firms (Figure 6).

Figure 4: Surge of corporate profits



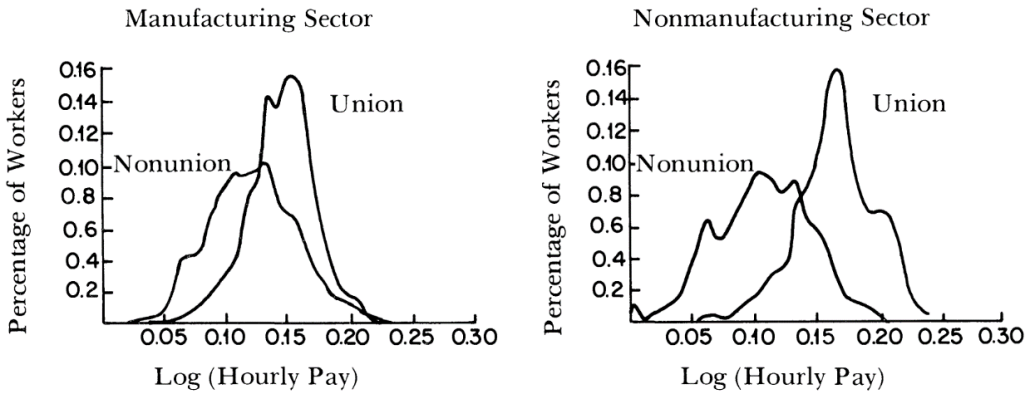
Source: Fred data set, US economy

Figure 5: Declining unionization rate and increasing income inequality.



Source: Gordon and Eisenbrey (2012), US economy.

Figure 6: The more egalitarian wage distribution under unionization (firm level analysis)



Source: Freeman (1984), US economy.

Trend 4: A tendency toward a winner takes all dynamics especially in the knowledge economy

Concentration and "monopoly capitalism" are quite well-known traits of capitalist development (Hilferding 1910; Lenin 1920), but new traits are emerging in relation to the role of big-tech companies in what we could call *rentification of capitalism*.[8]

First of all, these companies are experiencing an unprecedented market capitalization completely *unrelated* with the *value* and the price of the products they sell. Far from any relation to the market fundamentals, the extremely high capitalization of these companies relies on the speculative bets by financial markets about massive ownership of individual data which allows both consumers but even citizens profiling (think of the case of Cambridge Analytica). These tech companies are actually valued not for the products they do but rather for the knowledge they possess and the ensuing power they master. This is highlighted by Figure 7 showing the shares of the big-tech companies among the top one hundred transnational corporations, in terms of market capitalization, profits, physical assets, revenues. Strikingly, while the market concentration in terms of sales remains unaltered in the period $2000-2015$, the share of market capitalization and profits significantly increase. Going back before the Dot-Com crisis, Figure 8 shows that the former almost doubles between 1996 and2015, while the share of employment in the same period remains roughly constant (around 25% of total employment of the top non-financial firms).

In fact, to appreciate the uncoupling between real market dynamics and financial one, just compare the $Fortune500$ list (2018),[9] ranking firms in terms of their revenues, with the $Fortune$ list ranking them

8 In the late 20th century it was common wisdom that information and communication technologies would have rendered industrial organization less concentrated and more distributed: we take issue at such view analysing concentration patterns in manufacturing until the new millennium in Dosi et al., 2008. However the big jump in the overall concentration comes with the explosion of information intensive firm, such as Google, Facebook, etc.: see Andrews et al. 2016.

9 http://fortune.com/fortune500/

in terms of profitability.[10] Walmart is first in the former, and only $20th$ in the latter. Conversely, Facebook is $76th$ in the first list and $12th$ in the second one.

Another side of the *rentification* of the economy is the financialization of non-financial firms, entailing the use of the profits they generate from their businesses to fund financial investments for the companies themselves or to increase the wealth of their shareholder (Lazonick and Mazzucato 2013; Lazonick 2014). As a result, companies such as Amazon, Google, Apple, Facebook control more financial assets than many of the top investment banks. Together, many firms increasingly use their profits to buy back their own shares instead of undertaking physical and research investments, with the exclusive intent of asset appreciation for their stockholders.

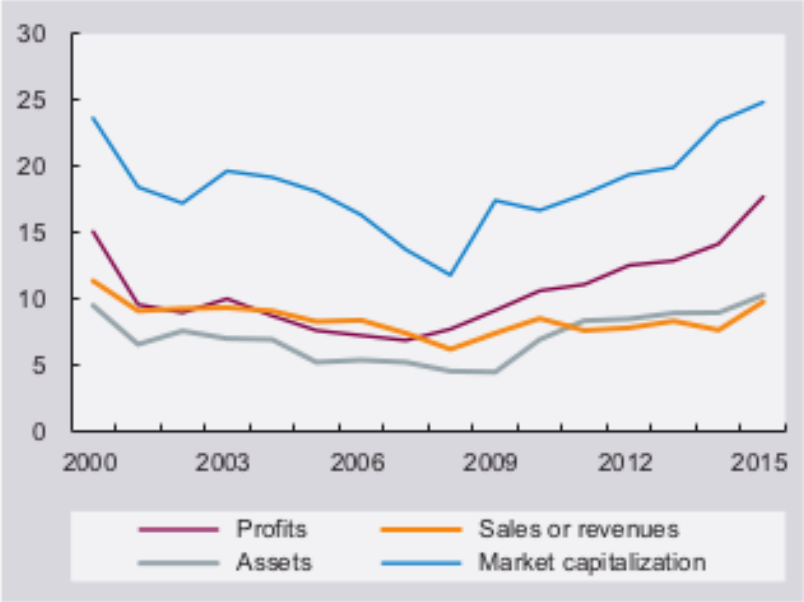
Note that the notion of rentification used here is much more expansive than the notion of financialization, but it includes it. The latter properly refers to the changing balance between real investments and financial ones. The former regards the very mechanisms of generation and of appropriation of the social product. Rents have always been there (recall Ricardo's discussion), but historically have been a "parassitical tax" on the process of transformation of inputs into outputs: in Ricardo's example, capitalists hire workers to plant and harvest corn, but in order to do that they have to pay some share of the value added to the rentiers.

A first form of further rentification is the exercise of monopoly power over what is produced. For example Big Pharma companies charge prices which have nothing to do with the cost of production but are just "the maximum the buyer is willing to pay". However, when capitalism becomes rentified the processes of value creation and those of value extraction become increasingly de-linked. The latter does not rely any more on any transformation function. It conversely rests on three other processes, namely, exclusion, "marketisation" of previously non-economic activities, and their appropriation. Exclusion works via the creation of fictitious value of physical and immaterial assets stemming from limitations to the access to them. This is clearly the case of real estate rents: after all, an apartment in Manhattan and a house in the Bronx satisfy the same basic need: however, granted exclusion, their exchange values are dramatically (and increasingly) different. Exclusion concerns more generally all "positional" goods and services (Hirsch, 2005) where the "value" comes from the very exclusion of other potential users (e.g. visiting alone the Galapagos islands).

Another major driver of rentification comes from the marketisation of activities that were previously (fully or partly) outside the market domain: health and education are two major cases to the point. Appropriation, or better, digital appropriation, consists in the extraction and collection of individual immaterial assets (mainly data) with the aim of monetizing them (see Section III). Exclusion, "marketization", and appropriation seem nowadays to make ever-higher claims on the total social product in the form of huge rents.

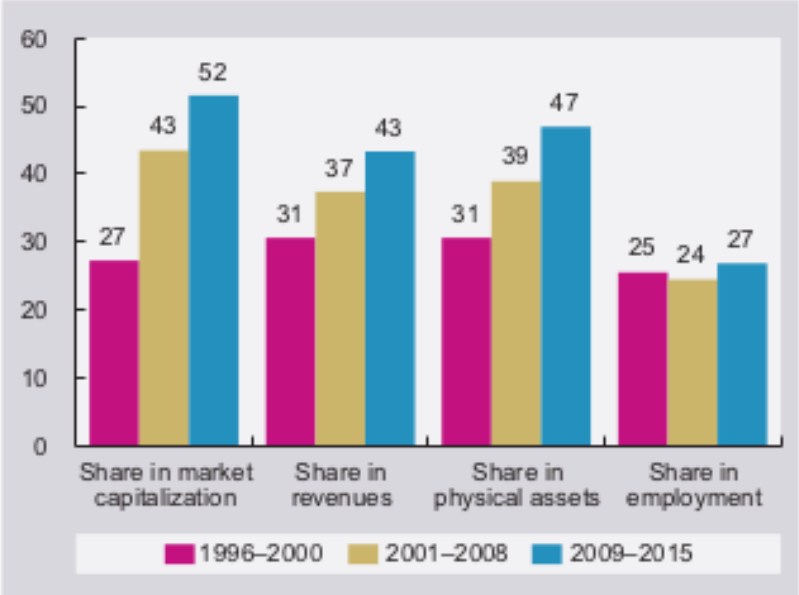
[10] http://fortune.com/fortune500/list/filtered?sortBy=profits&first500

Figure 7: Shares of big-tech companies in top 100 non-financial corporations.



Source: UNCTAD Database, elaboration of Thompson Reuters, (Trade Development Report 2018) p. 80

Figure 8: Shares of big-tech companies in top 100 non-financial corporations



Source: UNCTAD Database, elaboration of Thompson Reuters, (Trade Development Report 2018) p. 80.

Trend 5: Polarization and casualization of work

The service economy, where the largest fraction of the working population is nowadays located, is undergoing rapid transformations increasingly characterized by non-standard and flexible forms of labour relations and contractual regulations. This is linked to deteriorating patterns of working conditions, neo-Taylorism, both physical and digital, and to an equally profound deterioration in the legal protection of gig-workers' rights.

All the foregoing factors may well threaten societal, political and economic sustainability also because they affect the universality of the welfare system in domains such education, health and pensions, deepening inequality in opportunities and actual living standards. And, indeed, the may interact with and amplify the effects of technological changes. But, what type of technological changes are we talking about?

III. The emergence of a new techno-economic paradigm?

The massive introduction of robotized work certainly characterizes the industrial sector, with robotic devices able to substitute for repetitive and routinized activities. However, artificial intelligence and software developments are becoming increasingly relevant also in the service sectors, which, to repeat, nowadays employ the largest labour share. As a direct consequence, robotization and AI do not represent a threat only for blue-collars workers, but for the white-collars as well. If the ability of the IBM's Deep Blue computer to defeat the world chess champion Gary Kasporov did not come as a great surprise, because in a chess game human heuristics can be substituted by a complete search of highly dimensional, but still finite, combinatorics of moves, the new grand challenge undertaken by IBM software developers in 2004 was to program a computer, Watson, able to beat the human champion in Jeopardy. Unlike chess, Jeopardy is an open ended game that requires pronounced learning, linguistic, semantic, and association abilities. That was a big challenge as the latter cognitive capacities are not at all usual characteristics of computers. In 2011 Watson was able to beat two world champions in Jeopardy demonstrating the ability of the machines, not only able to compute, but to understand, learn and react according to changing information and environments. A view is that indeed machines might be heading to become "intelligent". Robots are nowadays able to compose music, write newspaper articles, grade high schools exams, paint artworks, play the piano. If it so, not only low cognitive abilities, but also higher ones may be potentially threatened by technology.[11]

Are these good or bad news? In fact, many emerging companies in the Silicon Valley or in the Boston Area are explicitly meant at creating and developing technologies able to entirely substitute for human labour. Momentum Machine is a start-up company founded with the aim of completely automatize the production of gourmet hamburgers. The founders explicitly state how their device is not meant at increasing labour efficiency but at getting rid of human labour force altogether (Ford 2015).

[11] Indeed, together with some episodes of success there are plenty of failures, like the use of the MOOC platform to spur on-line learning which resulted into a debacle in its ability to promote education for low-income students (Ford 2015).

Conversely, sectors like medicine and health care are still missing robots and machine learning algorithms whose massive usage could be complementary to human activity rather than replacing it. Potentially, there is ample room to go well beyond the use of robots and artificial intelligence in already standardized sectors -like fast-food production and delivery- to much less standardized ones like medicine and health care, whose costs are disproportionately increasing, threatening the right to health care of a soaring fraction of the population both in countries which have universal coverage (like most of Europe) and those which do not (like the US).

Is all this a "Fourth Industrial Revolution" or rather part of some incremental deepening and convergence among pre-existing technological paradigms? The question is very important as it is at the core of the analysis of continuities and discontinuities of knowledge basis, of the institutions and firms generating and supporting them, and of the national location of leading actors. Here we need to distinguish between the so-called "Industry 4.0" managerial and policy strategies, on the one hand, and the evidence which might support the arrival of a breakthrough technological revolution, on the other. With respect to the latter, a series of industry studies on the manufacturing sector which look at the technological and organizational implementation of Industry 4.0 (see Cirillo et al., 2018), hardly see any new sign of the emergence of revolutionary change inside the I4.0 factories. In general, the organisational changes accompanied with the adoption of I4.0 technologies find a pattern of general continuity with the lean production paradigm (Womack et al., 2007). In many respects, the I4.0 strategy, fostering "leanness" in the production system, hardly represents a paradigm shift. Rather, the drive towards customisation, reduction of inventories, elimination of bottlenecks, tracking of errors, intensification and saturation of working time overlaps remarkably with the first wave of lean production which began in late 1970s.

What might hint instead at a paradigmatic change concerns more the pervasiveness of the collection and the use of data to achieve control over the social/reproduction spheres of individuals. In 2014 the State Council of China released a document launching a new pilot project, the Social Credit System. The project, whose name simply resonates with some form of welfare state intervention, actually represents the first Government-endorsed program wherein *'Big Data meets Big Brother',*[12] intended to rank individual citizens with respect to their degree of social conformity. By means of a massive collection of individual data, mapping the entire social spheres of people, the program is meant to condition the possibility of e.g. getting the desired job, choosing the school for one's own children, having freedom of travelling abroad, etc. on the individual degree of trustworthiness. For obvious reasons the ranking algorithm is closed source and proprietary, although five factors are known to be at play: being a good tax-payer, a good borrower (in the sense of meeting deadlines), together with personal and interpersonal characteristics, preferences and behaviour. The system provides both rewards (such as free loans) and punishments (such as restricting mobility) and is managed by a credit service company related to Alibaba Group. Clearly, the possibility, leveraged by big-data collection and analytics, of regulating the entire social sphere of individuals represents the most extreme form of digital control.

12 See 'Big data meets Big Brother as China moves to rate its citizens'. Wired (online), 21 October 2017. https://www.wired.co.uk/article/chinese-government-social-credit-score-privacy-invasion

On the other end of the world, such control opportunities are currently massively exploited by high-tech companies. Recently, Zuboff (2015) introduced the notion of a new regime of capital organisation, called 'surveillance capitalism'. In this respect, the Chinese 'Big Brother' becomes the American 'Big Other': at core of this new accumulation regime lies the process of data generation/extraction, data analysis, and data selling. In that, there are several steps.

The *first* layer is largely a human-intense activity which ranges from consumer unintended data generation, whenever transactions on individual consumption patterns occur, up to piece-work activity based on click farms or generically crowdwork platforms and micro-work activities (such as Amazon Mechanical Turk) (Casilli, 2017; Huws, 2014). Not only humans, but also machines, and particularly robots, when integrated by means of sensors, become data generators. Such a pattern is particularly relevant for the industrial sector. This is basically an activity of *extraction* as in the majority of cases data are simply appropriated, even by means of intrusive and brute-force practices, like data storage or illegal penetration on individual privacy. In this sense, this current phase of capital accumulation appears closer to a rentier-economy rather than to a productive capitalist one, wherein both producers and consumer/workers enjoy the benefits of the value creation process.

The *second* layer consists of massive profiling of consumers/users by means of artificial intelligence, a computationally intensive process mainly relying on supervised (e.g. artificial neural networks) and unsupervised (e.g. text-mining and natural language processing) machine learning techniques. The *final* layer is data selling: the generated profiles are bundled and sold to other companies who then attempt to manipulate individual behaviour through targeted advertising. All this strengthens the tendency of creating new consumer needs to a higher, unprecedented level, delivering ads and contents directly to those consumers who are already known to exhibit the highest absorptive potential.

The Big Other turns out to be basically as coercive as the Big Brother. In fact, power becomes so pervasive that a given set of actions is not chosen because of the fear of control, involving conscious self-control and sense of conformity, but is perceived as one's own personal idea, regarding for instance the best restaurant, travel destination, accommodation, political preference, etc. And this occurs because the algorithm is influencing and predefining not only the repertoire of admissible actions, but also of conceivable ones.

IV. Technology, productivity and growth

Given the foregoing historical patterns, let us get into more detail concerning in general the relation among technology, productivity and growth. In a first approximation, technological progress is the core driver of economic growth: since the Industrial Revolution, when mechanization and specialization in the industrial production has been introduced, machines helped human activity in improving the quantity (and also the quality) of production (Freeman, 2019; Dosi, 1984). In turn, technological innovation translated into productivity, and the latter into economic growth. But this is just a first, and indeed quite rough approximation. To see this, consider the identity:

$$g_y = g_\pi + g_n$$

From an accounting point of view this is just an identity which tells us that the growth rate of aggregate income y is given by the sum of the growth rate of productivity π and the growth rate of the working population n. In terms of theory of growth, however, it is much more complicated. In order to say that it is the growth of productivity and demography which straightforwardly drive growth of GDP, necessary conditions are the assumptions that: (i) the initial conditions are equilibrium one; (ii) the rate of growth of employees corresponds to the rate of growth of labour supply – i.e., the system is in equilibrium at least in the long-run, whereby there is no involuntary unemployment and no endogenous changes in the participation rates; (iii) productivity growth is exogenous, or even if endogenous, there is no feedback between income growth rates and productivity growth (hence, no "Smith-Young-Kaldor" dynamic increasing returns). Here, however, we shall advocate a quite different story.

It is an evident stylised fact of modern economic systems that there are forces at work which keep them together and make them grow despite rapid and profound modifications of their industrial structures, social relations, techniques of production, patterns of consumption. We must better understand these forces in order to explain possible structural causes of instability and/or cyclicity in the performance variables. It might be useful to start from a more explicit definition of "dynamic stability" and "homoeostasis". We probably live in the first social structure where *technological*, *social* and *economic* changes are fundamental features of its functioning. For the first time, what we could call the "bicycle postulate" applies: in order to stand up you must keep cycling (Dosi and Virgillito 2017). It is the very growth and development of the system which yields the conditions of its (imperfect) coordination. However, changes and transformations are by nature "disequilibrating" forces. Thus there must be other factors which maintain relatively ordered configurations of the system and allow a broad consistency between the conditions of material reproduction (including income distributions, accumulation, available techniques, patterns of consumption) and the thread of social relations. In a loose thermodynamic analogy, it is what some French works call "regulation". The problem of long term discontinuities or innovation waves, which might induce changes in the rates of macroeconomic activities, pertains precisely to this level of analysis: are there structural features which produce crises in the "Regulation" set-ups?

Let's distinguish three main domains of the overall socio-economic fabric: (i) the system of technologies, (ii) the economic machine, (iii) the system of social relations and institutions. These three domains clearly interact with each other. Our analysis will build on the following hypotheses:

- Despite powerful interactions, each of these three domains has rules of its own which shape and constrain every inducement and adjustment mechanism between them.
- There is a limited number of configurations of these three domains which allows a relatively well-regulated and smooth consistency between them.
- Unbalanced or crises configurations do not necessarily also embody the necessity of the transition to other ones.

In capitalist economies where conflict over labour processes, income distribution and power are structural features, labour saving is bound to be one of the fundamental dimensions of most technological trajectories. Moreover, any labour saving upstream, i.e. in the production of commodities which are also productive inputs, represents an input-saving, in value terms, downstream. Developed

industrial systems are functionally characterised, in normal conditions, by reproducibility and not scarcity, demand-pulled in terms of macroeconomic activity, and balance of payment constrained. Under these conditions, paramount importance must be attributed to the broad duality of technical change which on the one hand continuously saves labour and, on the other hand, creates new markets or expands existing ones by means of changing costs and prices of each commodity and services. The balance between demand creation and labour displacement defines the endogenously generated rates of macroeconomic activities and utilizations of the labour force. The dual economic features of technical progress are affected by the pattern of consistency (or the mismatching) between:

- the nature of the fundamental technological paradigms;
- the nature of production and labour processes associated with them;
- the mechanisms of interactions among the major social groups;
- the baskets of consumption, which are a function of income levels, income distribution, and given the latter, of the ways societies organize the use of non-working time, the provision of services, etc.

Years after the Great Recession, European growth is still anaemic and there are increasing concerns that the crisis has permanently slowed down productivity growth, thus reducing long-run growth perspectives, recalling the notion of hysteresis.[13] Concerning the US, looking over the last two decades, (Syverson 2017) has recently documented that productivity growth more than halved between 1995 and 2015, moving from 2.8% (1995-2004) to 1.3% (2005-2015). A similar pattern characterizes 29 out of 30 countries analysed in the same study, with an average decline of 1.2 percentage points.

But, are we really facing the exhaustion of innovative opportunities? Or are we rather witnessing the exhaustion of a growth regime characterized by a smooth matching between product and process innovation, productivity gains, their distribution as wages increases, sustained formation of aggregate demand and, ultimately, sustained GDP growth?

Certainly, at least since the Industrial Revolution, The Unbound Prometheus (Landes 1969) of technological innovation has driven mechanization and specialization in the production processes together with the generation of increasing variety of products, leading to a secular increase in productivity and per capita GDP. That happened throughout the different industrialization waves (or Industrial Revolutions) characterized by different techno-economic paradigms (Freeman and Perez 1988) from the steam engine all the way to a potential current Fourth Industrial Revolution. However, some scholars argue, such a secular drive has been exhausted, both in terms productivity growth and of creation of new investment and consumption opportunities comparable to those associated with the revolution in the means of transport, urbanization, central heating, electrification, etc... (Gordon 2012). Are such social needs exhausted? Hardly so.

Most likely the sources of the productivity slowdown are diverse, potentially attributable to many, possibly complementary causes. Some pertain to the supply side, including lags in the diffusion of the latest wave of new technological paradigms and lack in organizational capabilities and skills apt to fully

13 More in Dosi et al. 2018a.

exploit them. After all, major new technologies such as the electricity-based ones took roughly one century in order to display their full potential. Conversely, nowadays we are just at the start of the digitalization of the economy and of society – based on the convergence, among ICT, automation and Artificial Intelligence – and we are still beginning the exploration of the potential of Bio- and Nano-technologies, and new materials. Other possible causes of the apparent productivity slowdown pertain to the demand side and to the interaction between the latter and the rate and direction of innovative efforts.

For sure, well before the Great Recession, the strikingly successful socio-economic regime of growth observed during three Glorious Decades after World War II came to an end as the smooth matching among technological innovation, productivity growth, income distribution and aggregate demand increasingly broke down (see Section 2). To recall, on the technological side, the sustained rate of growth was based on the rapid development of few fundamental technologies such as automobiles, electrical consumer durables, capital equipments related to mass production and Tayloristic production processes. On the institutional and labour side, some sort of inclusive social compromise guaranteed relatively equal income distribution, a rough indexation of wage on productivity growth and political commitment to near-full employment. In turn, the foregoing conditions on income distribution fostered sustained growth of consumption, optimistic animal spirits regarding investment and the overall growth of aggregate demand.

In any case, it is crucial to notice that our discussion, so far and below, is well distinct from a comparative examination between the "techno-optimist" view (e.g., Brynjolfsson, and McAfee, 2014) and the "techno-pessimism" one (e.g., Gordon, 2012). Both views are fundamentally postulated on some intrinsic nature of the new technologies and some direct link between trends in technology, productivity and growth. On the contrary, especially at junctures like the current one, the ultimate outcomes will stem from the interaction between what major social actors, such as firms, organized labour, civil society, and States, will do. A point that we want clearly to deny is that the richness of such dynamics could be squeezed into the estimation of the changing parameters of an otherwise invariant production function. By the same token, we find hard to take seriously any interpretation of the rates of employment and its remuneration in terms of work/leisure trade-offs,[14] and ensuing partial derivatives of aggregate productivities to specific skills. We may head either to "work for all" or "mass unemployment" (Freeman and Soete, 1994) and that will depend entirely on us.

V. Technology and jobs

The impact of technology upon labour demand works through a variety of channels and has been one of the thorniest issues at least since David Ricardo's chapter "On Machinery". As know, it is often referred to as the problem of *compensation mechanisms* (Vivarelli 2014). There are at least four channels linking technological change, demand and employment, namely first, via productivity growth to lower

14 Conversely, it is hardly believable that the bifurcation will be driven by any choice of some "representative worker/consumer" determined by the relative price of leisure, as extreme versions of equilibrium theory would suggest. Working poor certainly do not work more than before because the cost of watching Netflix (which is basically free) has increased.

prices to higher demand (under positive price elasticities); second, from productivity growth to growing real wages to higher demand, and third, with an opposite sign, from productivity growth to labour displacement to higher unemployment and lower demand. On the other side, fourth, product innovations have always created new sources of demand, together with new forms of employment. Thus, what has happened and is happening to the relative importance of product- vs process-related technological advancements. Has it changed? And in which direction?

Of course, there is a sectoral dimension to such dynamics. At a bird-eye view, historically the pattern of economic growth has been associated with a movement of the labour force from agriculture to manufacturing, and finally to the service sector. The prevalence of the effects of labour-creation or destruction accompanying the process of structural change basically boils down to whether output growth (demand) is higher/lower than productivity growth. Demand growth and productivity growth are linked via the price elasticity channel: productivity dynamics, in so far as it reduces prices, it spurs demand in sectors experiencing high productivity growth (see the classic Kuznets 1955; Clark 1957; Baumol 1967; Pasinetti 1983).

The other driver of dynamics rests in the income elasticities of demand: employment absorbing sectors (toward which the labour force tends to move) have been generally characterised by high income elasticity of demand, especially in the initial phase of development (Freeman, Clark, and Soete 1982). While high income- and price-elasticities of demand might compensate, or more than compensate, the labour saving effect of process innovation, under conditions of increasing returns demand growth influences productivity dynamics (the so called Verdoorn-Kaldor law). Such virtuous circles apply primarily to manufacturing and certainly were at work during the Glorious Decades. Are they still at work now?

In the past, the transition from agriculture to industry meant a shift from lower productivity toward higher productivity sectors, characterized at the same time by high income elasticities of demand; and so was the evolution within industry itself from traditional manufacturing to consumer durables (such as cars, white goods, TV, etc). Conversely, nowadays the manufacturing activities associated with the new technological paradigms are indeed high productivity sub-sectors (e.g., ICT, robotics, biotechnology) but (still) bear a relatively low share in aggregate demand and in employment.

Together, the bulk of the transition nowadays appears to be from manufacturing to services – prima facie characterized by an apparent lower productivity. Certainly there is here a major issue of measurement, as it is hardly possible to compare with the same yardstick the value added of health care with that of car manufacturing. However, it holds that in relatively wealthy, ageing, societies, the share of health services, elderly care, other welfare services are growing and bound to further grow in the future. Indeed the healthcare sector might be a source of a new wave of innovations and technological developments. But it is hard to imagine increasing return processes similar to manufacturing, almost mechanically linking demand growth and productivity growth, however measured. In turn, this entails a formidable policy challenge (see below). Of course, the process of automation and robotization of industry and increasingly service have, and more so will have, profound effects upon labour

productivity.[15] Indeed this is going to be one of the major objects of investigation in the years to come, together with the lag structure by which the related innovations are likely to diffuse throughout the economy.

Technological innovation obviously exerts a major impact on jobs, both on their quality and quantity. Many scholars have recently been studying how the introduction of new technologies have affected the set of worker-skills that firms *demand* (see Autor 2015, for a review). According to Autor, along the entire skills range, automation and computerization turn out to be *substitutes* for the more routinised activities and *complement* for high-skilled non-routinised jobs, with more limited effects on low-skilled, non-routinised jobs. The outcome of these dynamics suggests a pattern according to which medium-skilled jobs will gradually disappear, together with a relatively stable or increasing demand for both low-skilled and high-skilled jobs. The consequence of the simultaneous relative growth of demand for highly skilled/high-wage workers and low-skilled/low-wage workers suggested leads to a process of both wages and skills polarization.[16]

In turn, the change of the skill composition might also have effects on the ability of the Western economies to regain pre-crisis occupational level (see Jaimovich and Siu, 2012): the extent to which routinised (both manual and cognitive) skills have been and will be automatised can contribute to the explanation of the jobless recoveries. Indeed, the decreasing trend in routinised skills has been particularly severe since the 1991 recession. Prior to that period, routine occupations – despite being hit – were able to effectively recover. This was combined with a generally increasing trend (even in the recession period) of non-routine occupations. However, since 1991, skills associated with routine occupations were not only severely displaced in the recessionary phase, but also never managed to recover. In particular, after the 1991 and 2001 recessions, recovery of the pre-crisis employment rate appeared in fact mostly driven by increasing trend in non-routine occupations. After the Great Recession, more worryingly, routine occupations have been hit particularly hard and, for the first time since 1970s, non-routine occupations also declined.

The notion of routinization above discussed often comes with a simplistic view of the relationship between automation and tasks. In fact, the fundamental link between technologies and operational tasks goes through *organizational routines* (more in Section 6). Moreover many studies conclude that the sources of inequalities have little to do with any purported skill/routine biased technical change, but they rest in the dismantling of labour market institutions (more in Freeman, 2015; Dosi et al., 2018b).

It is also paramount the role of structural change across sectors. Jaimovich and Siu (2012) report that job losses in manufacturing accounted for 38% of job polarization since the nineties. In this respect, Groshen and Potter (2003) investigated whether the process of structural change could be associated with jobless recovery, focusing on the 2001 crisis in the United States.[17] Groshen and Potter (2003)

15 This is not the place to discuss why we focus on labour productivity and not so called Total Factor Productivity (TFP) as many economists do. Suffice to say that in a world where capital inputs and labour are complements, and where the former are produced under conditions of non-decreasing returns, TFP measures are likely to be meaningless or even misleading.

16 For a cross-country comparison on the dynamics of routinised jobs see Marcolin, Miroudot, and Squicciarini, 2018.

17 In some countries like US there is an apparent fall in unemployment rate, but this is mainly due to the fall in the active population and the growth of involuntary part-time jobs (Bell and Blanchflower, 2018).

suggest that the process of structural change has been a determinant of jobless recovery, highlighting the predominance of permanent job losses over temporary and the shift of jobs across industries. In fact, they argue that the evidence of very low rehire rates militates in favour of the hypothesis that fired workers generally found jobs in other firms and sectors. Distinguishing between cyclical and countercyclical flows, and between structural gains and losses, they suggest that, while the downturns during the seventies and the eighties were characterised by a mix of cyclical and structural adjustments (50% respectively), the share of structural adjustments increased to 57% and 79% respectively in 1990-91 and 2001. Needless to say, such changes in the economic structure of the U.S. (and more generally Western) economies are intimately related to the rise of China as the World Factory discussed above.

Further evidence on the connection between job polarization and structural change is discussed by Bárány and Siegel (2018). The authors propose a model in which they link the tripartion of skills (manual, routine and abstract) proposed by Autor, Levy, and Murnane (2003) with low-skilled services, manufacturing and high-skilled services respectively. They argue in favour of a strong overlap between the routine-skills categories and industry-occupation categories. In particular, the dynamics of the share of manufacturing and that of routinised skills appear to be quite similar. Furthermore, examining in depth the industry occupation-categories, Bárány and Siegel (2018) suggest that the decline of routine activities is deep and persistent only in the manufacturing sector. Conversely, routine activities in low-skilled and high skilled-services, they suggest, display an increasing trend or stability, respectively.

Granted that, of course, the *overall quantity of jobs* should be a major analytical and policy concern. The threat of *technological unemployment*, given the massive use of automated processes that can substitute for human labour is an issue that concerns the micro, sectoral and macro dynamics. We discusses the relation between innovation and employment at micro and sectoral level in Calvino and Virgillito (2018) and focusing on China in Dosi and Yu (2018). The evidence broadly suggests a positive relationship – primarily with respect to product innovations and primarily in inter-firms comparisons. However, it could well be that more innovative firms grow more also in terms of employment but that it could well happen at the expense of other firms, so that the overall effect might be negative. In order to properly address such issue one is bound to consider the sectoral and inter-sectoral dynamics of innovation and employment. And indeed such general disequilibrium perspective is still largely missing.

An alternative angle of analysis entails the exploitation of geographic differences in some proxies for innovation propensities and in the composition of employment, building a sort of geographical job multiplier (Moretti, 2012). The conjecture is that high-innovative sectors have a higher multiplier as high-tech jobs in the tradable sector appear to be attached to many more jobs in non-traded sectors. The idea is that high innovative sectors are those where high productivity increases occur, and such productivity gains, transferred into high incomes, trickle down to the demand of non-tradable goods.

Many criticisms apply however to this storytelling. First, information-intensive technologies are likely to generate far less jobs than traditional manufacturing ones. So, a leading new-tech firm like Google is employing a number of people an order of magnitude lower than a traditional/declining firm like General Motors. If that comes together with a much more unequal income distribution, as it does, it becomes straightforward that the ratio of productive vs non-tradable workers is likely to be lower in the Silicon Valley than in Detroit. But it is a purely statistical picture of more unequal techno-economic

dynamics. Second, one should go beyond pure compositional exercises and we should pay much more attention not only on the number of jobs created, but also on the quality, and salaries, of created jobs. Otherwise one might easily end up in a servant-ridden society, where rich people have dozens of individuals who satisfy their own personal needs. Third, highly unequal societies are likely to be associated with collective negative externalities. So, for example, high-income jobs tend to determine a surge in living costs, and, particularly exploding home prices.

With wage stagnating and increasing lay-offs, these patterns add to both rentification of the economy discussed earlier, and the worsening quality of life of the majority of the population. Consider homelessness in the mythical Silicon Valley. Although still accurate analyses are dramatically lacking, a big chunk of the increase has been due to the arrival of high-tech firms which have induced a tremendous increase in housing costs, with a one bedroom apartment costing 3,000$ per month, that an engineer gaining around 80,000$ gross annually is not able to afford. All this should alert about the new patterns of job creation resulting from this capitalism 4.0.

> As of 2014, the city [of San Francisco] is believed to have approximately 7,000 homeless residents. As of 2015, approximately 71% of the city's homeless had housing in the city before becoming homeless, while the remaining 29% came from outside of San Francisco. This figure is up from 61% in 2013. Of that 71%, 51% had lived in San Francisco for less than 10 years before becoming homeless; 11% had only lived in San Francisco for a year before becoming homeless. By 2016, according to a report by urban planning and research organization SPUR, San Francisco had the third highest per capita homelessness rate (0.8% or 8 in 1000 persons) of all large US cities, as well as the third highest percentage of unsheltered homeless (55%).[18]

Relatedly, one should start questioning the extent to which big-tech firms are genuine creators of new knowledge and what can justify the enormous inequality they are producing by exercising predatory behaviours upon the information distributed across the society. So, in many cases, the "knowledge" they produce is recombinatorics of existing pieces of information, with the aim of creating purportedly new needs to be satisfied, or better, to satisfy very old needs with purported new technology. Take the case of social networks: they mainly serve for chatting, gossiping and meeting people but they transfer these very basic and old human needs into a virtual, unknown reality. Together, these systems extract more value than what they create by monitoring people, tracking and selling consumer profiles.

VI. Division of labour, knowledge and power

The very nature of the capitalist organization has always involved the power of organizing labour. Historically, this occurred by means of the rationalization of the production process way back since the First Industrial Revolution which entailed a combination of new technological paradigms and organizational innovations. As Adam Smith masterly noticed, the division of labour within organized units dramatically increased productivity, and it did so by transferring knowledge from disorganised artisans and part-time farmers into hierarchical forms of production. In so doing, the initial phase of capitalist development has entailed a first massive process of labour deskilling. Indeed, successive waves followed, from the "Taylorist movement" to the present. Braverman, 1974 analyses such

[18] https://en.wikipedia.org/wiki/Homelessness_in_the_San_Francisco_Bay_Area

dynamics in contemporary capitalism, detailing the micro-organization of the so called *labour process*: the working class is analysed in its relationship with the machine, the shop floor, its management and the related control. The management structure under capitalism is such that the knowledge embodied into workers should be transferred into machines. In this respect the process of technological change has entailed a secular deskilling tendency whereby the machine makes codifiable what before was tacit knowledge (Nuvolari 2002).

To understand the relationship between man and machine it is crucial to understand the evolutionary process driving technological change. Think of a technology as a *recipe* with 'ingredients', associated procedures and "admissible acts" required, e.g. to build an artefact. A recipe always embodies a degree of codified knowledge but must be complemented by non-codified and tacit one (the non-written procedures). In turn, the procedures are typically collective implying mechanisms of coordination among members of the organisation. The execution of the recipe coordinated among the members of the organisation entails an ensemble of *organisational routines*. Organisational routines constitute therefore a *trait d'union* between technology and organisation, typically nested into hierarchical structures and power relations (Dosi and Marengo 2015). Figure 9 illustrates the point. Given the tacit nature of knowledge embodied in the execution of complex tasks, a "natural trajectory" in technical progress has involved the progressive mechanization/automation of production processes and a drive to make the routines simple, repetitive, and codified. Control over rhythms of productions, correct execution of tasks, movements along the sequences of production, and discipline of the workforce have been and are the necessary conditions for the codification of knowledge.

Figure 9: The relation between capitalist organization, knowledge and power

While these patterns have always been there since the emergence of capitalist societies, indeed a birthmark of them, it seems that they are now accelerating. More or less intelligent automation is heading toward the very disappearance of quite a few of the foregoing tasks and related jobs, at least as they are performed by humans. Will all that be compensated in a comparable number by intelligent jobs? It is hard to predict, but one can hardly see signs for it: even the rather optimist analyst sees a large multiplier in terms of gardeners, baby-sitters, hairdressers, and we would add janitors and, that being America, prison guards and policemen.

There is another major feature of current technological transformations which represents *discontinuities* vis-a-vis older patterns, and that concerns the "dematerialization" of some sources of aggregate income. All that is intimately connected with a significant part of social activities grounded on technologies that are more akin "information" as ever before, especially on the output side, but also on the input one, as discussed above, yielding a form of *privately appropriated information*. A good case to the point are *platforms*, characterized by the combination of near-zero marginal costs of access and reproduction, with strong economies of scale, and network effects (David 1985). In order to appreciate it, let us briefly consider the specificities of information as an economic good (more in Dosi and Nelson, 2010). First, information is non-rivalrous in use. Use by one economic agent in no way by itself reduces the ability of other economic agents to use that same information. Second, sheer information involves high up-front generation costs as compared with lower costs in their repeated utilization. In fact, there is something genuinely special of information in general and also of technical knowledge in that they share a sort of notional scale free property. So, in a first approximation, an idea when fully developed does not imply any intrinsic restriction on the scale of its implementation. In a language which we do not particularly like, were there a production function with information as the only input, it would display an output equal to zero for an information below one unit and a vertical line for information equal one. Nowadays platforms approach such an archetype. Fourth, as a consequence, there is a fundamental increasing returns property to the use of information.[19] The use of standard economic goods, ranging from shoes to machine tools, implies that use wears them out. This does not apply to information. On the contrary, the persistent use implies at the very least its non-depreciation.

Now, consider together the foregoing dynamics in the division of knowledge, power, and control together with *centralization and appropriation of information*. The former are actually leading to more hierarchical power, even if often hidden under the reduction of hierarchical layers. Such reduction ought to be taken on the contrary as a tendency toward a more polarized social fabric: "...one king and its subjects...". Put that together with the contemporary use of platforms which exploits the properties of the economics of information. The inherent characteristics of the latter entail general non-convexities, Matthew-effects[20] and self-reinforcing processes implying multiple equilibria and trajectories. The two dynamics might be explosive: blending together tighter hierarchies with more information-driven centralization, when unrestrained, may lead to easier exploitative behaviours and massive polarization in the distribution of power, knowledge, and incomes. Think of Uber as an example: the major cost is the set-up of the platform and the marketing for it. Once running, the cost of its maintenance and expansion (marginal costs) are near-zero, while the delivery of the service is done through the exploitation of the service providers themselves, the car-drivers and their own cars. This is not to say that all current candidates to become information monopolists will survive. In fact, by definition, they are "unicorns" doomed to failure, but in the meantime they will have radically changed the industries in which they operate (Kenney and Zysman, 2016).

19 All this entails a strong drive to monopoly, making even more far-fetched the possibility of any "contestability" (cf. Baumol, 1986). Increasing returns and path dependency precisely stand against any representation of industrial organization which are so "fluid" that even nominal variables (prices) are as sticky as real stock variables (e.g., fixed investments), a necessary condition for "contestability".

20 From the "Parable of talents", in Matthew's Gospel: *For to every one who has will more be given, and he will have abundance; but from him who has not, even what he has will be taken away.*

The gig-economy[21] is an even more extreme archetype. Algorithms govern labour, no human beings against whom one can strike. There is "little" hierarchy: no one between you and the algorithm. And you are alone, as well many thousands of others, in a pre-industrial condition, similar to the "putting out" system before industrial factories. But, at least then, English peasants doing part-time flexible jobs were able to cheat, steal some of the fabric, control their pace of work.

The case of bike-delivery workers, who are nowadays populating the streets of metropolis is another revealing example. These workers use a relatively old, human intensive mean of production (a bike) to provide a service which satisfies an old, basic need, as the one of eating, controlled by an extremely sophisticated software which acts as a boss, tracks and monitors workers, and sends productivity evaluation messages (time to accept orders, time to deliver, travel time to restaurant, travel time to customers, late orders). However, according to some legislations, drivers can't be deemed employees because they have no obligation at all to log on to the app (Uber). A FT interview[22] to a Ubereats worker documents how the app may immediately change the salary without incurring in any legal implication. The app started paying 20 pounds an hour, then it moved to 3.30 pounds a delivery plus 1 pounds a mile, minus a 25 per cent "Uber service fee", plus a 5 pounds "trip reward". Then the "trip reward" had been cut to 4 pounds for weekday lunch and weekend dinner times, and to 3 pounds for weekday dinner and weekend lunch times.

General characteristics of *Digital Taylorism* entail: being based on cheap, generally educated workers, without a workplace, fictitiously convinced of being "their own bosses". Their type of contract typically transfers the entreprenerial risk from firms to workers. In this respects the power usually represented by a boss is enforced by an algorithm that communicates with workers via smartphones. This division of labour results into the disappearance of both collective and even individual labour contracts (De Stefano 2015).

Together with this form of *Digital Taylorism*, old forms of Taylorism are still largely in place, particularly in the World Factory Economy (China). In this respect, the Foxconn case is almost an archetype (Ngai et al. 2015), among the biggest worldwide employers and top among Chinese exporters. Its hiring strategy is mainly taking advantage of the massive migration from agricultural areas of young workers (born after 1980s), it is organized as a factory-cum-dormitory (Dormitory Labour Regime), with extreme forms of control, with checkpoints and guards standing by 24 hours a day. The factory assumes control as a "total institution" (in the meaning of Foucault) controlling not only the working time, but the entire sphere of human activities. All employees, whether they are going to the toilet or going to eat, must be checked. Physical and verbal violence is systemic in Foxconn system. Workers are harassed and beaten up without serious cause. All this resulted for example into 18 suicides committed in 2010.

> To die is the only way to testify that we ever lived...Perhaps for the Foxconn employees and employees like us – we who are called nongmingong, rural migrant workers, in China – the use of death is simply to testify that we were ever alive at all, and that while we lived, we had only despair.

21 For a further discussion on platform-economy see (Kenney and Zysman 2016).

22 https://www.ft.com/content/88fdc58e-754f-11e6-b60a-de4532d5ea35

Such an internal hierarchical structure is matched by an international division of production and a value chain which sees Apple squeezing their suppliers. Correspondingly in order to secure contracts, Foxconn minimizes costs, and transfers the pressure of low profit margins to front-line workers. Workers are paid at an average wage quite close to the province minimum wage, massively relying upon overtime hours. Nothing of this is particularly new, and applies more widely than the ICT segment. Walmart is another archetypical example. The foregoing cases vividly illustrate how, from the application of ICT-based technologies to the production, the management of the value chain may lead to forms of "turbo-Taylorism" which look like some "hight tech" versions of the horrors of the factories and Work Houses of the First Industrial Revolution.

VII. Some policy scenarios, by way of a conclusion

In the policy debate, there is finally an increasing recognition that something should be done facing the serious increase in inequality, potential massive unemployment, the deterioration of working conditions and slippage of the welfare state. However, discussions are generally partial (a one problem at the time approach) and too often grounded in the interpretative paradigm of the economic orthodoxy - grounded on market frictions, rigidities, mismatching, or at most market failures-, based on the presumption that markets left to their own means most often can efficiently take care of themselves and by implication take care of all of us. So, for example, there cannot be, by construction, long-term technological unemployment.

We should of course assess the efficacy and the possible trade-offs of alternative policy packages concerning, for example, redistributive policies, taxation in a globalized and digitalized world, education and training policies, employment policies, innovation and industrial policies. But we have to consider them together. And, even more important, the discussion should be placed in the broader context of a transformation of the relations between human beings and work, and between individuals and institutions. Alternative policies will result in different configurations of the State and of intermediate institutions – the spectrum ranging e.g. from lean to thick States, from individualistic to collective forms of actions, from public to market-based provision of public services, indeed with quite different implications not only in terms of income growth, but also – and equally important – inclusiveness, the distribution of work and income, and ultimately of power.

Alternative policies concerning labour market institutions include: co-determination with some workers control on corporate strategies, workers ownership, and, at the opposite end of the spectrum, basic and or universal income and minimum wage. Of course, the distributional and social implications are rather different. For example, micro institutional engineering involving workers ownership, and/or profit sharing, or even German-type *mitbestimmung* are schemes with the burden of redistribution placed upon the single employer/firm, probably quite effective at the local level, but also prone to differentiating elite workers from the rest. Thus, if it has the advantage of increasing the labour share and redistributing productivity gains at firm level, it has the disadvantages of exacerbating across-workers inequalities, while being relatively ineffective in addressing aggregate unemployment and possibly also cause of conflict between different groups of workers.

Conversely, the bottom of the distribution tends to be addressed by more universalistic schemes such as forms of basic income. However, they are equally controversial. If they provide a safety net for every citizen, their implementation tends to be at best neutral in terms of general income redistribution. In fact, it is generally advocated together with very strong reductions of the welfare state, implying the transformation of public goods, such as health and education, into (private) income transfers. Recall that Milton Friedman was among the first proponents of the universal negative income tax. Additionally, basic income schemes might be politically biased in so far as the right to access might be linked to the citizenship status, raising fundamental issues of discriminatory treatments vis-a-vis the pool of non-citizens. Increasing the minimum income level might help as well in putting a floor to the labour share which is dramatically falling. However, it might weaken the unions' bargaining power and threaten the collective organization of workers. And in any case, it cannot redress overall income distribution.

In that, taxation will continue to play a major role. New and old forms of progressive taxation ought to be implemented. Particular attention should be devoted to the understanding of both the dynamics of the tax-base and the ways different types of income, whether profits or wages, and rents (financial and non-financial) have to be taxed. The contemporary pro-market fury has come together with an anti-tax drive which has heavily reduced the redistributive impact of fiscal policies and the universalistic provision of services. For sure, such a drive has to be reverted together with the relative balance of taxation rates: more on rents and wealth than on profits, more on profits than on wages. As well known, there are growing problems in capturing rents and profits, beyond the nil political will to do it – related to their footloose nature –. However, the technical means are there, as profits and more generally financial flows can be tracked from the countries of origin to the countries of destination, generally fiscal heavens.

Moreover, the objects of taxation might also be changing. So, new forms of taxation including the robot tax, the bit tax and the web tax should be at least discussed. Some scholars suggest that "who owns the robots rules the world" (Freeman 2015). South Korea has recently introduced a robot tax and the issue is also being debated in the European Parliament. However, while the robot-tax is likely to slow down the adoption of labour displacing technologies, it is still not clear whether such taxation should be on the ownership or the use of robots. In fact, it seems much more reasonable to tax the owners: otherwise it would have been like, in other epochs, to tax locomotives instead of taxing railroad tycoons. Moreover, robots might have very different usages, many of them not aimed at substituting but at complementing human activities (such as medical and bio-robotic applications), in very diverse activities, ranging from agricultural, to industrial and service sectors.

Another proposal is the *bit-tax*, already in the policy discourse since the beginning of the nineties (Soete and Kamp 1996). As the transactions and the produced incomes are more and more immaterial, the tax base should shift from physical units toward digital units, which is bits of transmitted information. The *web-tax*, taxing digital transactions, might be consider a form of bit-tax. The taxation of platforms is another open question of great relevance. Platforms are increasingly using individual assets (such as apartments) to gain corporate profits. Additionally, distributed assets give rise to highly centralised rents.

In addition to income policies, one ought to consider employment policies. Some are indirect and affect the characteristics of labour supply. Education and training policies come under this heading. And so do so-called active labour market policies, involving training of unemployed people and retraining of workers in order to cope with skills obsolescence. While certainly essential, such policies are arguably hardly sufficient and additional more direct policies might be required (Dosi et al. 2019). Firms should not expect to hire ad-hoc trained employees, but rather they have to be pushed to invest in enhancing employees' learning, mainly via on-the-job training schemes. In order to cope with rapid technological advancement workers should first of all possess a wide range of non-task specific skills. Higher level reasoning and abstract skills have to be taught and developed.

An approach which dates back at least to Roosevelt's New Deal holds the State as *employer of last resort*. Contrary to any notion of a lean State, this view implies the creation of massive job-programs during periods of downturns, with the double advantage of doing useful things and providing income (Minsky 1986). Last but not least, employment policies concern the reduction of working-hours. After all, this has been the secular tendency in industrialised countries since the mid 19^{th} century, matching the long-term patterns of mechanisation and automation of production. It has been recently tried in some advanced countries with the aim of enabling at the same time the creation of new jobs opportunity, and the redistribution of productivity gains. And certainly such measures ought to be matched by strong regulatory limits to involuntary part-time works, non-standard forms of employment and mini-jobs.

The State has always been creator of investment opportunities, backer of long-term and risky research programs and herald of "mission-oriented" innovations (Mazzucato 2015). It should be even more so now. A fundamental objective ought to be policies fostering the creation of human-enhancing innovations in contrast with human-replacing ones. The tall task is to develop ambitious mission-oriented programmes able to foster the emergence and diffusion of new technologies and to shape the directions of the ensuing technological trajectories. The imperative on such directions ought to be environmental and social sustainability, and income redistribution. In fact, the public has to recover its ability not to only regulate, but to clearly mould the strategies of private actors.

We have emphasized above how information-intensive activities entail dramatic increasing returns to information itself. In turn, that tends to lead to (quasi) monopolistic or tight oligopolistic structure of supply. Think of Google, Amazon, Airbnb, etc. How to deal with the socio-economic consequences of such trends? An obvious measure are competition policies as the EU has recently began to implement. Will that be enough? Probably not. When "natural" monopolies tend to emerge, history teaches, the State needs to introduce tight and thorough regulations or even consider nationalization. In the past, this has been the case of telecommunication and other utilities, railroads, etc. We should not shy away from such polices today in presence of the strongest drive to monopolization since the inception of capitalism.

We are facing nowadays a historical bifurcation both in technological trajectories and in the forms of socio-economic organisation. We can head towards some form of techno feudalism with a deeply divided society or we can go towards a society that collectively share the benefits of technological advances. The taken route largely depends on the kind of policies we design and implement.

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