Le grandi questioni sociali del nostro tempo
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The Social Consequences of the Digital Revolution

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Abstract This article reviews the major issues and discussions related to the impact of the digital revolution on labour. First, it emphasizes that the current digital revolution in manufacturing and services is not a revolution in the sense of a sudden technological breakthrough. It rather argues that the major reason for today's lively debate about digital technologies is a new strategic interest in a strong manufacturing sector as foundation for global competitiveness. Second, this article discusses the potential effects of digital technologies on employment. It argues that the aggregate effects on employment could be positive – depending on many other factors but in particular on the underlying social forces and power relations. Increasing inequalities might be a more problematic development than the pure destruction of jobs. Third, this article shows that the new technologies could lead to increasing standardization and surveillance of work and workers. It discusses the potentials to avoid such developments and promote the redesigning of work organization, which leads to empowerment, an enrichment of work, and an improvement of working conditions. Finally, the article discusses the impact of the platform economy, and in particular crowdwork, on labour relations.

Keywords Digitalization. Automation. Employment. Labour process. Platform economy.

1 Introduction

For several years now, the media has frequently reported about new achievements in automation. Robots and algorithms, it is said, will cause dramatic changes in how work is organized and will ultimately replace human labour altogether. These fears are nicely illustrated by the March 2014 edition of the Economist, whose front page read "Rise of the Robots". The associated article on digitalization started with the following words: "Prepare for a robot invasion. It will change the way people think about technology" (*The Economist* 2014).

But are these fears justified? If the digital revolution is in fact taking place, what will its consequences be? The answers to these questions are quite controversial, not only among the general public but also among

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academics. In this chapter, we review the current research with a focus on two core questions:

1. What is really new about the technological developments that are expected to change our working lives and what is driving the current debate about the digital revolution?
2. What will the potential impact of this technological change be on employment, skills, and job quality?

Our contribution is based on a literature review and two current research projects,[1] and is structured as follows. In section 2, we first discuss what the term digitalization means, what developments it includes, and to what extent it actually represents a revolutionary break with the past. Second, we present and compare different explanations regarding the drivers of digitalization, some of which focus on technological innovation and others on socioeconomic transformation processes. Section 3 looks at the debate about the impact of digitalization on employment and on social inequalities. The major questions in this debate are how digitalization will change skill requirements in jobs and what jobs might be replaced by computers or robots. In section 4 we turn to the debate about the impact of digitalization on the labour process and discuss the available evidence. While some developments suggest that digitalization may increase technological labour control, others show the possibility of using digitalization to bring about organisational innovation and improve working conditions. In section 5 we shift focus from the established industries to the platform economy, which is a new field of economic activities and a new form of organizing work. We focus here in particular on crowdwork, a completely new phenomenon linked to digitalization. Our article concludes with a summary of arguments and findings.

2 What is New about Digitalization and What is Driving the Change?

The current public debate suggests that we are going through a period of accelerated automation characterized by the introduction of robots and artificial intelligence into our workplaces on a broad scale. It is useful to remember, however, that such discussions and prophecies are not new. Robots have been in use in the automobile sector since the 1970s, and since the 1980s, welding shops in car factories have been almost completely automated. In the food and electronics sectors, automation has gone even further than in the automotive industry. Accelerated technological change

1 "Between digital bohemia and precarity. Work and performance in the crowd" (Fritz Thyssen Foundation) and "Wearable computing in manufacturing and logistics" (Hans Böckler Foundation).

is a well-known phenomenon in the manufacturing and service sectors and a core topic of labour sociology, because revolutionizing the productive forces is a constant imperative of capital. This process has occurred in waves, which have provoked recurring research debates. The relationship between automation and skills has been a core issue at various points in time: during the introduction of the first robots and numerical control machine tools (Noble 1986), during the introduction of computer-integrated manufacturing concepts in the 1980s and 1990s (Adler 1992; Brödner 1990), and also in the current discussion.

These waves of technological change have been accompanied time and again by radical prophecies about technology replacing humans, as Peter Brödner (1997) illustrates in his critical deconstruction of cybernetics and artificial intelligence theories. As an example of such prophecies, he cites Herbert Simon and Allen Newell, who argued in 1958

> 1. That within ten years a digital computer will be the world's chess champion, unless the rules bar it from competition. 2. That within ten years a digital computer will discover and prove an important new mathematical theorem. 3. That within ten years a digital computer will write music that will be accepted by critics as possessing considerable aesthetic value. 4. That within ten years most theories in psychology will take the form of computer programs, or of qualitative statements about the characteristics of computer programs. (Simon, Newell 1958, 7)

While the first forecast only came to pass in 1996 – 28 years later than forecast – the other three predictions are still fiction. But if the use of robots, computers, and high automation is nothing new, what exactly is new about the current digital revolution. Is it a revolution at all? Let us cast a brief glance at the major elements of the current technological change.

A core topic related to automation is the development of so-called 'cyber-physical systems', i.e., self-regulating constellations of objects (machines, but also parts) that communicate through the internet of things (Holler et al. 2014) and make use of new technologies such as sensors and real-time computing techniques. In one of the initial documents of the German *Industrie 4.0* platform, the authors described this development as follows:

> In the future, businesses will establish global networks that incorporate their machinery, warehousing systems and production facilities in the shape of Cyber-Physical Systems (CPS). In the manufacturing environment, these Cyber-Physical Systems comprise smart machines, storage systems and production facilities capable of autonomously exchanging information, triggering actions and controlling each other independently. (Forschungsunion, Acatech 2013, 5)

A second important development in the field of automation is the emergence of new, flexible lightweight robots that 'leave their cages' and are capable of working side by side with humans. There are other similar trends that do not represent automation; these include so-called digital assistance systems (tablets, data glasses, smart watches etc.). Some authors echo Herbert Simon's prophecies from the 1950s and also mention artificial intelligence solutions as a way of automating some areas of white collar work (McAfee, Brynjolfsson 2017) – yet such developments are still more fiction than reality.

The third important transformation is the development of the so-called platform economy. Established companies such as Amazon, Facebook, Google, and Ebay, and newcomers such as Uber, Lyft, Deliveroo, and Upwork have created digital infrastructures (platforms) that enable a wide range of activities. Together, they have prompted a reorganization of markets, value creation, and value capture and have ultimately given rise to a reorganization of work. This development has been facilitated by an array of new information and communication technologies and in particular by the movement of computable algorithms to the easily accessible cloud (Kenney, Zysman 2016; Langley, Leyshon 2016).

One new form of work that has emerged within the platform economy is crowdwork (Gerber, Krzywdzinski 2017a). This term describes the growing outsourcing of tasks via internet-based platforms to external individuals who do these jobs online in the digital cloud from locations across the globe. The range of tasks is wide and includes simple data categorization or text writing as well as more creative and complex tasks such as design, product and service innovation, or scientific problem-solving. These tasks require neither employees nor offices anymore. The members of the so-called crowd are neither employed nor do they need to know the company they work for.

When we look more closely at these fields of technological innovation, we recognize that they build on older systems and that technological development is much more gradual than the current debate suggests. But why are we talking about a digital revolution taking place now?

There are two different explanations for this phenomenon. The first one sees technological innovation as the main driver of the debate. In their book *The Second Machine Age*, Brynjolfsson and McAfee (2014) emphasize the major role of Moore's Law. According to this law, the capacity of digital technologies doubles each year. In its initial form, this law was related to the amount of computing power that you could buy for one dollar. Brynjolfsson and McAfee argue that it also applies to a wider range of developments, for instance the speed of computers and data transmission, the installed computing capacity and so on. The exponential growth of technological capabilities leads to radical change and a radical acceleration of innovation at a certain point in time:

> Our quick doubling calculation also helps us understand why progress with digital technologies feels so much faster these days and why we've seen so many recent examples of science fiction becoming business reality. It's because the steady and rapid exponential growth of Moore's Law has added up to the point that we're now in a different regime of computing. (Brynjolfsson, McAfee 2014, 48)

There are various reasons to be sceptical about explanations that focus on technology. One reason is the well-known 'productivity paradox' of information technologies (IT) (Brynjolfsson 1993). For a long time, economists have discussed the paradox that the introduction and diffusion of IT in the economy does not seem to have any discernible impact on productivity. Daron Acemoglu, David Autor, and other researchers conclude in a recent paper (2014) that there is still no evidence of a productivity revolution due to IT.

A second reason to doubt Brynjolfsson and McAfee's purely technology-based reasoning is the alternative explanation for the current discussion, which was proposed by Sabine Pfeiffer (2017). Pfeiffer argues that, since 2010, we have been observing a policy change on a global scale. The 1990s and the 2000s were characterized by de-industrialization. Manufacturing was regarded as a relic of the past, while future economic growth was expected to be driven by the service economy and the financial sector. After the global financial crisis, a change occurred. On the one hand, the crisis showed that uncontrolled growth in the financial sector could have highly detrimental consequences. On the other hand, countries with a strong manufacturing base – like Germany – recovered much better from the crisis than other countries. The World Economic Form released several reports emphasizing the importance of a strong manufacturing base for economic growth and the need to invest in new technologies (e.g., World Economic Forum 2012). In the case of the United States, which had experienced a strong decline of manufacturing since the 1980s, advisors to the Obama administration issued a report calling for an "American Leadership in Advanced Manufacturing" (President's Council of Advisors on Science and Technology 2011).

The result of this change of strategy is a global competition and race for leadership in the digitalization process. It is expected that the first comer will be able to define the standards for the new industrial Internet and its applications. This would also mean that the first-comer country could sell technologies to other countries and thus create growth and employment. In Germany, the government, business associations, trade unions, and research institutions created *Platform Industrie 4.0*, which was intended to promote the development of new technologies (Forschungsunion, Acatech 2013). The French government launched a similar project under the name of *Industrie du Futur*. In the United States, a private initiative, the Industrial Internet Consortium, was founded in order to promote standards for the new technologies. But the activities have not been restricted to traditional industrialized countries. China started a huge program called *Made in China* 2025, which includes a high number of sub-initiatives that range from efforts to develop cutting-edge technology in robotics and the industrial internet to programs aiming at modernizing traditional labour-intensive industries by introducing conventional automation concepts (Butollo, Lüthje 2017). And there are many other countries with similar projects. These national programs mobilize public and private money and aim at accelerating technological innovation. They also include campaigns to mobilize all companies and sectors and encourage them to invest in these technologies and create a market for them. Finally, they also include PR campaigns to increase the acceptance of the new technologies among workers and the population in general.

Overall, it is clear that we should be careful not to attribute today's debate about the digital revolution to technological innovations only. After all, technology is embedded in social power relations. Its use and impact thus always depend on the agenda, preferences, and power of actors. Hence, behind this debate on the technological revolution, we must identify shifts in the strategies of global and national economic actors – multinational companies, international organizations, but also major governments – and a transformation of global capitalism.

3 The Threat of Unemployment and Inequality

Despite the efforts of national governments and business associations to promote a positive image of digitalization, the public debate remains strongly influenced by scenarios involving massive job losses and increasing social inequalities. One of the most influential papers was written by Carl Benedict Frey and Michael Osborne (2013), who tried to calculate the probability that different jobs would be replaced by robots or computers. Their conclusion is that 47% of all US jobs are in danger of being taken over by machines – a finding that received a lot of media attention. The occupations at risk are mostly in manufacturing, but also in sales, administration and other services.

Frey and Osborne pursue a specific approach to calculate the probability of computerization. They use a database from the US Department of Labour that includes information about more than 900 occupations. Researchers used the descriptions of these occupations to classify them according to three criteria:

- The first is social intelligence. It includes communication with other people, negotiation, persuasion, and care for other people. A dishwasher, for instance, needs very little social intelligence according to Frey and Osborne, while a public relations officer needs a lot.

- The second criterion is creativity, which means the ability to come up with unusual ideas as well as to compose and perform music, dance, theater etc. According to Frey and Osborne, a court clerk needs hardly any creativity, unlike a fashion designer.
- The third criterion is perception and manipulation. It describes a person's ability to move his/her fingers in a very precise way and to handle very small things, to move his/her hands very quickly, and to assemble complex objects, even in awkward positions. A telemarketer needs no particular manipulation skills, while it is a core requirement for a surgeon.

Frey and Osborne distinguish between high risk occupations (which have a probability of being automated that is higher than 70 percent), medium risk occupations, and low risk occupations (probability below 30 percent). Based on their estimations they argue that

> 47 percent of total US employment is in the high risk category, meaning that associated occupations are potentially automatable over some unspecified number of years, perhaps a decade or two. (Frey, Osborne 2013, 38)

It is important to note that according to this argument, many service jobs will be automated in the long run, because they are highly routinized. This may even affect high-skill jobs like those in programming. Many programming jobs include largely routine activities and are heavily based on logical deduction and formal rules. In manufacturing, for instance, companies are already working on applications that will be able to derive the programming code for machines directly from technical drawings. In contrast, some low-skill jobs remain relatively immune to computerization or automation. Manual tasks like cleaning, hairdressing, or health assistance, but also some areas of manual production represent daunting challenges for automation because they require very precise and flexible manual skills that cannot be mastered by robots.

Despite their finding that some middle-skill jobs are threatened by automation and that some low-skill jobs are relatively safe, the analysis presented by Frey and Osborne shows a clear linear relationship between the education level required in a certain occupation and the probability that a certain occupation will disappear due to computerization and automation. While highly skilled employees seem relatively safe, digitalization is likely to threaten lower skilled employees – resulting in unemployment or pushing their wages down as they have to compete with ever-cheaper automation solutions (Brynjolfsson, McAfee 2014, 125f.).

Frey and Osborne's argument has received a lot of attention and faced considerable criticism. The first objection relates to the unit of analysis. Occupations – which is their unit of analysis – encompass a broad mixture of tasks. Some of these might be routine and susceptible to automation, while others are not. Analyses that focus on tasks and not on entire occupations have come to very different conclusions regarding the dangers of computerization and automation. Bonin et al. (2015) showed that in a model based on tasks and not occupations, only 9 percent of US jobs are in danger of being replaced by computers or robots.

Pfeiffer (2016) emphasizes that a large number of low skill and routine jobs still require a lot of implicit experiential knowledge that cannot be formalized. Even in these types of jobs, workers frequently have to cope with unforeseen situations and problems and are confronted with often changing working conditions due to changes in the production process, product specifications etc. Pfeiffer argues that Frey and Osborne failed to include such factors in their analysis and hence strongly overestimated the feasibility of automation.

In addition, Autor (2015) emphasizes that in most cases, automation will not replace complete occupations and jobs, but rather complement them and simply change the tasks of human workers. A prime example is bank tellers. When ATMs – automated teller machines – where introduced in the 1970s, many people expected the occupation of tellers to disappear. As Bessen (2015) shows, the opposite was the case. Despite the diffusion of ATMs, the number of bank tellers in the US increased. There were two developments: On the one hand, the number of bank tellers per branch fell. But on the other hand, the number of urban bank branches increased. As routine cash-handling was now performed by machines, bank tellers were transformed into salespersons responsible for maintaining customer relations and selling additional bank services.

Researchers have also pointed out that it is difficult to estimate the impact of technology on employment without taking the broader macroeconomic dynamics and social forces into account (Autor 2015; Bonin et al. 2015). By reducing the cost of some activities, automation can free up resources and create employment in other areas. By increasing productivity, automation can also generate new demand and hence employment. There is no simple relationship between automation and aggregate employment.

In saying this, we do not intend to trivialize the impact of the new technologies. Nor do we mean to say that all jobs are safe. There is some evidence from the last decades that technological progress has led to a polarization of the employment structure (Autor, Dorn 2013; Goos et al. 2009). A recent study from the OECD (2017) argues in a similar vein. The study uses occupational statistics from 1995 to 2015 and comes to the conclusion that the polarization of employment structures increased considerably. The study classifies occupations into low-skill, middle-skill and high-skill ones. The findings for Western Europe are, for instance, that the share of low-skill jobs in total employment increased by 2.7 percent while the share of high-skill jobs increased by 7.6 percent; by contrast the share of middle-skill jobs decreased, by 9.8 percent. Based on a multivariate model, the OECD (2017) argues that digitalization is the major factor behind this process.

While the OECD's findings fit with several other studies, it is important to point out that the data on which this study (as well as many others) relies is very weak. The classification of occupations into low, middle and high skills is very rough. For instance, the low-skill category doesn't just include unskilled workers but also encompasses policemen, chefs, nurses, and caretakers. The measure of digitalization used by the OECD study – as the supposed driver of the polarization of employment – is even less nuanced: it is simply the amount of the companies' investments in IT services.

As our short review of the debate shows, the jury is still out on the question of how technological change influences employment and inequality. A major problem is the lack of data. It seems clear that technology will not simply replace labour – after all, it is still human labour that generates surplus value. Instead, it is possible that the impact of digitalization will be a polarization of employment structures and enhanced inequality. While the impact of technology is not completely clear, there are other developments that might have contributed even more to social inequalities: the deregulation of labour markets, the weakening of trade unions, the dismantling of the welfare state, and the increasing global competition. Instead of blaming technology, it might be more reasonable to criticize that failure of regulation and the (active) retreat of the state.

4 The Transformation of the Labour Process

New control regimes are another issue in the current digitalization debate. Ford (2015) and Carr (2014) describe scenarios in which the workers will become mere servants of ever 'smarter' computers and robots, whose complexity will increasingly defy workers capacity for understanding. Moore and Piwek (2015) emphasize the opportunities for control and monitoring that are opened up by the new wearable technologies (data glasses, smart watches, smart textiles). Reports on the use of wearables at Tesco and Amazon show that this technology can be used to analyze employees' productivity data, movements, and interactions. The case of a Tesco distribution center in Ireland has become particularly well-known (Wilson 2013; Rawlinson 2013; Moore, Robinson 2015). In this case, the warehouse workers wore 'smart' bracelets that assign their tasks and measure their movements. Their pay was directly linked to their measured work performance.

Many aspects of this debate about the transformation of the labour process due to new technologies are not really new (Howcroft, Taylor 2014; Briken et al. 2017). The most prominent theory regarding the links between technology and control in the labour process was formulated by

Harry Braverman (1974). According to Braverman, the use of technology is mainly determined by the interest of the management in improving control over the work process and the workers:

> Thus, in addition to its technical function of increasing the productivity of labour – which would be a mark of machinery under any social system – machinery also has in the capitalist system the function of divesting the mass of workers of their control over their own labour. (Braverman 1974, 193)

Braverman's pessimistic scenario of technological control of labour has not remained uncontested in the labour process research (cf. Wood 1982; for a critique, see also Attewell 1987). Thompson and Harley (2007, 149) stressed that "the notion of the workplace as a contested terrain is a central motif of LPT" (labour process theory). Workers' tacit knowledge and their capacity to disturb the labour process are regarded as key factors that can block the introduction of new technologies or compel management to take workers' interests into account (Hall 2010). It should not be assumed that the workers' knowledge and experience can be completely replaced by automation or controlled through technical systems – they remain an important resource for the management, which forces the management to ensure consent is maintained when introducing new technologies (see also Krzywdzinski 2017).

There are many factors influencing the use of technology and its impact on the labour process: the power relations in the workplace, the nature of the labour process, the characteristics of the value chain and the sector. According to all these factors, we observe very different approaches to digitalization (Krzywdzinski et al. 2015), as a few examples show in the following.

Deskilling and a focus on using digital technologies to achieve control seem to be dominant in companies and sectors that have long pursued paths based on the standardization of work and lean production, which experience high cost pressures, and which are characterized by weak trade unions and employee representation in general. An example is the logistics sector. So-called pick-by-light and recently pick-by-vision concepts (Reif, Günthner 2009) are becoming more and more common in logistics companies. Pick-by-vision systems link data glasses worn by logistics workers with companies' order management systems. The order management systems provide information about which items have to be picked from the storage area, where those items are located, and in what sequence the logistics worker should pick them. Step by step, all the information is displayed on the data glass and instructs the worker in each and every operation. The camera in the data glass or the RFID chips worn by the worker confirm that the right article has been picked. The digital control of the labour process is nearly total.

Companies have experimented with very different forms of motion control. In the MotionEAP research project funded by the German Ministry for Economic Affairs (Bundesministerium für Wirtschaft und Energie 2015), companies (among them the car manufacturer Audi) and research institutions have developed a sensor- and video-based control system that recognizes problems or mistakes in the work process (e.g., workers picking wrong parts, doing the tasks in the wrong sequence, or working in an unergonomic posture). In such cases, the system projects a warning directly onto the wall where the worker is located. The goals of the project even go beyond motion control: The aim is to recognize and analyze the facial expressions of workers in order to recognize stress situations.

Other projects show, however, that digital technologies could transform existing labour processes so as to benefit the workers. Again at Audi, a remarkable pilot project promises to break with the fundamental principles of production organization in automobile assembly and link radical technological innovation with organisational innovation (Basic 2016). Audi is experimenting with a new way of organizing car assembly without an assembly line – the project represents a revival of the modular assembly systems developed in Sweden in the 1970s and 1980s and abandoned in the 1990s due to the turn to lean production (Sandberg 1994; Jürgens 1997). Digital technologies are breathing new life into this approach. The sequence of assembly steps is no longer defined by the assembly line. Instead, a digital control system recognizes which assembly cells are occupied and which are free. Self-driving transportation units bring the cars to the assembly cells. Other self-driving units are responsible for supplying the cells with material and parts. The cells are equipped with smart shelves that adapt to the worker's position in order to avoid unnecessary journeys to pick parts. Workers are no longer forced to adapt the pace and rhythm of their work to the assembly line. And if a problem arises, which in the past could threaten to stop the whole assembly line, the new system adapts and uses the capacities of the unaffected assembly cells as far as possible.

5 The Platform Economy, Crowdwork, and Precarization

Digitalization is not only changing the labour process within established companies, but also challenging the idea of organizing the labour process within a company or other organizational entity in general. The aforementioned platform economy and crowdwork are two models that could represent a complete change in how work is organized. Instead of a work contract, crowdworkers 'have' terms and conditions. As the members of the crowd are registered as freelancers, they do not have access to entitlements such as sick leave, minimum wage, holidays, training, or co-determination. Crowdworkers work for a piece rate or on the basis of competitions; their income is volatile and insecure. From a broader perspective, crowdwork is linked to a more general trend towards work arrangements based on solo self-employment.

US platforms such as Upwork, Crowdflower, or 99designs have several million registered members. German platforms are smaller, with some ten to several hundred thousand registered members on platforms such as Clickworker, TestBirds, or Jovoto. We have to take into account, however, that not all registered crowdworkers are actually active. Our research suggests that only 10-15% of registered workers complete tasks or participate in competitions on a regular basis. Most crowdworkers seem to pursue this activity as a side job for an additional income while they study, raise kids, or do another job. An even smaller number of people actually make their living through crowdwork. While these findings (see Gerber, Krzywdzinski 2017b) suggest that we should not dramatize the dangers related to crowdwork, it is still a socially relevant phenomenon.

One can roughly distinguish between two types of tasks, which shape the way in which platforms structure the work process. On the one hand, platforms organize routine support tasks (e.g. short texts, data categorization) or tasks that do not require specific knowledge (e.g., software testing). These tasks can be disassembled into short standardized and clearly defined ‘microtasks’. On the other hand, complex ‘macrotasks’, which require a higher degree of knowledge or creativity (e.g., designs, software programs, product innovation) can be organized through crowdwork platforms. These macrotasks cannot be broken into pieces and often the goal is to crowdsource the best among many good solutions. Therefore, they are organized as competitions. As a result of these different logics, remuneration modes also differ greatly. The piece rate for microtasks is typically very low, ranging between a few cents or euros per task. In crowd competitions, the prizes are high (they vary from several hundreds, to tens of thousands of euros) but only one or few receive the prize money. They are selected by the client, a jury, or the crowd community.

Despite these different models, crowdwork has primarily become associated with the microtask approach. In particular the Amazon platform Mechanical Turk (AMT) has attracted much attention due to the often-criticized working conditions. On AMT, humans complete small, highly standardized microtasks (categorizing pictures, transcribing short audio sequences, writing short texts, etc.) for a few cents per task (Ross et al. 2010; Irani, Silberman 2013). In addition, the platform gives clients the power to reject work results and refuse payment and there have been reports that this power is often abused to retain the work results but avoid paying the workers (Irani, Silberman 2013). The crowdworkers have little capacity to resist, as access to future jobs on the platform depends on the rating given by the client.

In the public debate, fears are expressed that this type of work could result in a particularly extreme precariousness for the workforce. Another concern is the far-reaching standardization and intensified control of work. A number of scholars refer to crowdwork as the digital rebirth of Taylorism (Huws 2003; Brown et al. 2010; Kittur et al. 2013; The Economist 2015; Thompson, Briken 2017). Many scholars fear that this extreme standardization of the work process will allow both a new intensity of control and a new quality of technical control through algorithms. For instance, the platform Upwork, formerly oDesk, reports taking snapshots of the computer screens or counting the keystrokes of freelancers who are paid per hour in order to control their activity (Kittur et al. 2013; Judge 2016).

Interestingly, however, crowdwork actually shows the limits of automation. It demonstrates that even simple tasks such as photo tagging or data research require human labour and can be done more cheaply by humans than by computers. The limits to automation are captured in the name of the most prominent platform: Amazon Mechanical Turk. The name relates to Wolfgang von Kempelen's chess player automaton from 1770, which gave the impression that a Turk mannequin controlled by a sophisticated mechanism under the cabinet could play serious chess against opponents; in fact, it was Kempelen's human assistant hidden underneath who was playing (Aytes 2013, 81f.). Amazon refers to Kempelen's illusion in its marketing slogan: it proclaims AMT as "artificial artificial intelligence" and thereby openly admits that human labour is required to compensate for the shortfalls of artificial intelligence (Irani 2015a, 225).

Ekbia and Nardi (2014, 6f.; see also Irani 2015a, 2015b; Lehdonvirta 2016) argue that

> certain tasks that humans can perform are not impossible for computers, but would require expensive research and programming labour to be realized. In the long run, it might be more cost-effective for enterprises to automate labour performed by human workers […], but capitalists are driven by near term profits [hence] under current conditions, hiring people through short-term, benefits-free contracts that typically max out a few dollars per hour […] is less expensive.

While the possibilities for automating labour processes are not unlimited, a number of authors argue that labour governance can be automated to a certain extent (Irani 2015a, 2015b; Kittur et al. 2013; Ekbia, Nardi 2014). Prediction algorithms may be used to assess the accuracy of work results. Preprogrammed tests can automatically pop up before or between other tasks to check for quality and attention. Filtering and matching algorithms assign crowdworkers to particular tasks or ensure that workers who do not meet the criteria do not see these tasks. Within crowdwork, employees are regarded "as functionaries in 'an algorithmic system'"

(Ekbia, Nardi 2014, 7). Labour relations are "pushed into the server" (Irani 2015b, 226) and objectified more "than Ford or Taylor could have imagined" (Ekbia, Nardi 2014, 7).

This vision of labour control leaves, however, little room for the agency of the crowd. Our own empirical research on platforms organizing both microtasks and macrotasks shows that automated algorithmic control and surveillance of the crowd through the platform is limited and at best describes the situation on microtask platforms (Gerber, Krzywdzinski 2017b). Here, the fragmentation of simple tasks into standardized, clearly defined, and fault-tolerant task units allows for close control over the results. Surprisingly, this monitoring is, however, mainly done manually: either by the crowd, the platform's staff, or the client. Automatic control mechanisms like automated, preprogrammed tests before or between actual tasks or iterative tasks to algorithmically assess the accuracy of solutions are complementary.

Automation and control alone are hence not enough to regulate performance within the crowd. Our empirical findings show that mechanisms have emerged that drive performance primarily through ranking and digital reputation systems (see also Gandini 2014, 2016). These reputation-based systems consist of points attributed to each individual crowdworker for a variety of performance factors, including how well tasks were performed, the activity level, and community interaction. Platforms use these reputation systems to rank and segment crowdworkers according to their activity and quality of performance. The data collected within these reputation systems is used to decide which crowdworker is suitable for which kind of task. This process is mostly automated through so-called matching algorithms.

In addition, platforms harness the 'wisdom of the crowd' for themselves. Platforms build up their own crowd communities and promote social interaction as a central element of performance regulation. On the one hand, the community serves as a source of efficient control through peer-review and self-help mechanisms. The crowd ranks and comments on each other's contributions or flags spam and plagiarism. The community also trains newcomers by answering questions, providing tips, and helping with problems. Unlike reports on AMT, where no direct communication between the crowdworkers, the platform, or the clients is possible but such communication is efficiently mediated through "autopilot as an algorithmic system," (Irani, Silberman 2013, 614), our research shows that on most other platforms, platform employees are often itself very much engaged in these community discussions. Interaction within the community is often promoted by so-called 'gamification' elements, such as badges, trophies, or 'like' functions. Game elements are applied to a non-game environment to alter the crowd's behaviour, in particular by catering to intrinsic incentives such as recognition or competitiveness within the community (Scheiner et al. 2017; Blohm, Leimeister 2013). And for the client or platform, these rewards do not cost anything.

6 Conclusions

In our paper, we discussed the major issues related to the impact of the digital revolution on labour. First, we emphasized that the current digital revolution in manufacturing and services is not a revolution in the sense of a sudden technological breakthrough – although we do not want to trivialize the technological changes going on. But many of today's technological solutions are still part of a gradual change that started decades ago. And many of the technological promises that are discussed today will only fully impact in maybe 10, 20, or 30 years. The discussion about the impact of technological change on work and employment is not new and many of arguments and theories debated today link to concepts developed in the past.

We argued that besides technological innovations, an important reason that we are confronted today with a lively debate about the impact of the digital technologies is a strategic change on the part of the main economic and political actors. Before the global financial crisis, the main focus was on the financial and the service sector, while manufacturing was considered old-fashioned – it was called 'old economy'. After the financial crisis, major actors came to the conclusion that a strong manufacturing sector provides the best foundation for global competitiveness. We are now observing a race for technological leadership in manufacturing. And the debate in which this paper engages is the result of campaigns like *Industrie 4.0*, which aim to mobilize private and public actors to invest in manufacturing technology.

Third, we emphasized that automation could surely replace labour in some areas, but the aggregate effects on employment could also be positive – depending on many other factors but in particular on the underlying social forces and power relations. Besides substituting for labour, technology also creates new demand in the form of new investments and in increasing productivity, which leads to a subsequent reduction in prices of some goods. Increasing inequalities might be a more problematic development than the pure destruction of jobs. Several studies report a decrease in middle-wage routine jobs and a polarization of employment structures – even though they are often based on rather 'shaky' data. But this polarization does not necessarily have to be attributed to technological change. Regulation can address such developments, and we think that the deregulation of our societies is the main problem.

Fourth, we showed that the new technologies can be used to increase the standardization and surveillance of work and workers. We can expect a lot of tensions, dangers, and conflicts in workplaces in this regard. But once again, the workplace is a contested terrain. Technology as such also allows for the possibility of redesigning work organization, which leads to empowerment, an enrichment of work, and an improvement of working conditions.

Finally, we have discussed the impact of the platform economy, and in particular crowdwork, on labour and labour relations. Crowdwork constitutes a novel form of work, a field of experimentation in which new mechanisms of work and performance regulation are developed. We have to be aware of the structural limits of this form of work and also of its – at least at the moment – limited size. Nevertheless, crowdwork surely has considerable potential to lead to a further precarization of work and labour relations. We can also expect that the new modes of work organization and performance regulation developed within crowdwork (standardization, modularization, reputation systems, gamification) could in future also be used in established companies. Existing company workforces could be governed by digital reputations systems in the future or transformed into 'crowds'.

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