The Challenge of **Industry 4.0** and the Demand for New Answers

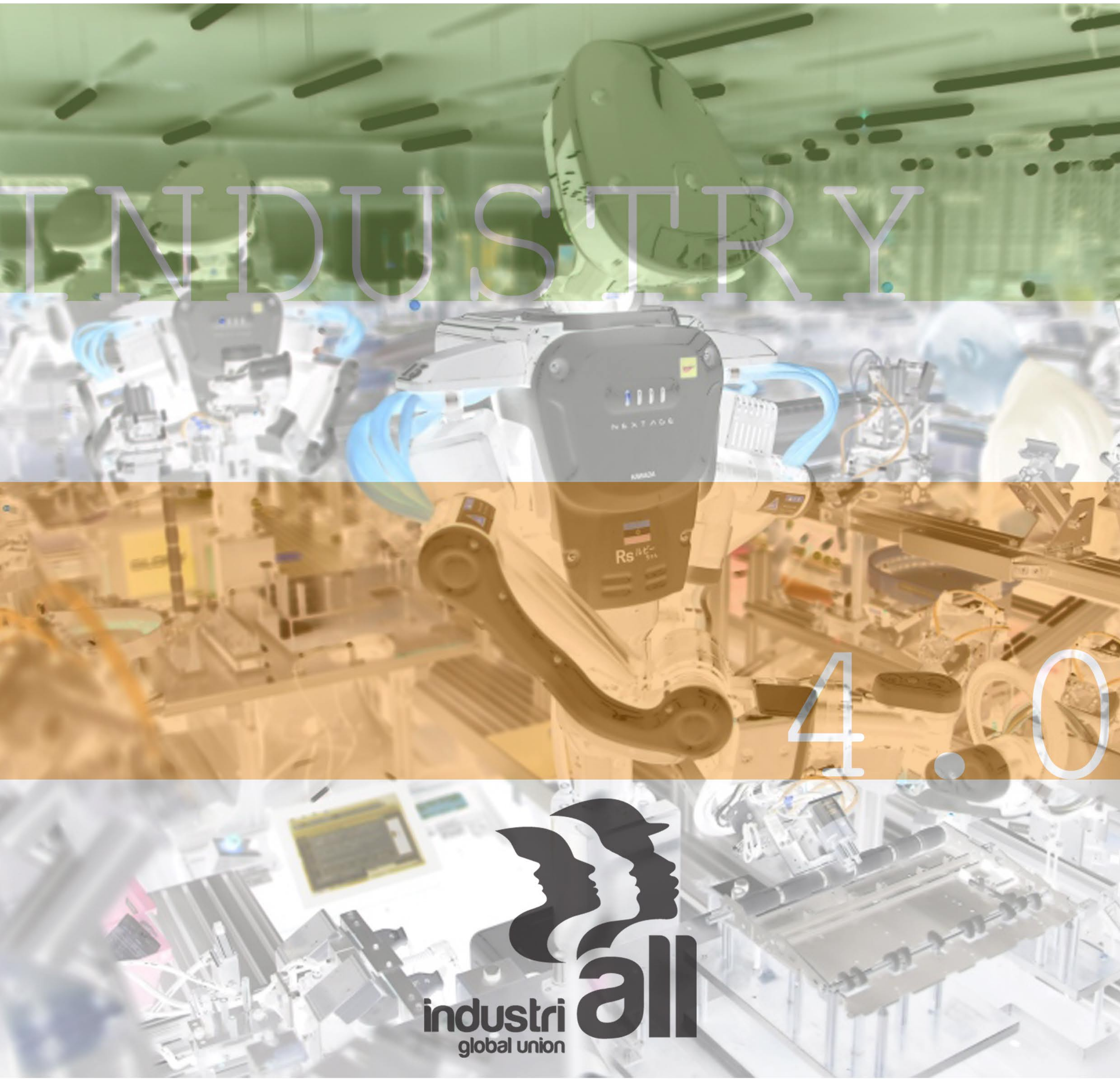

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TABLE OF CONTENTS

Introduction

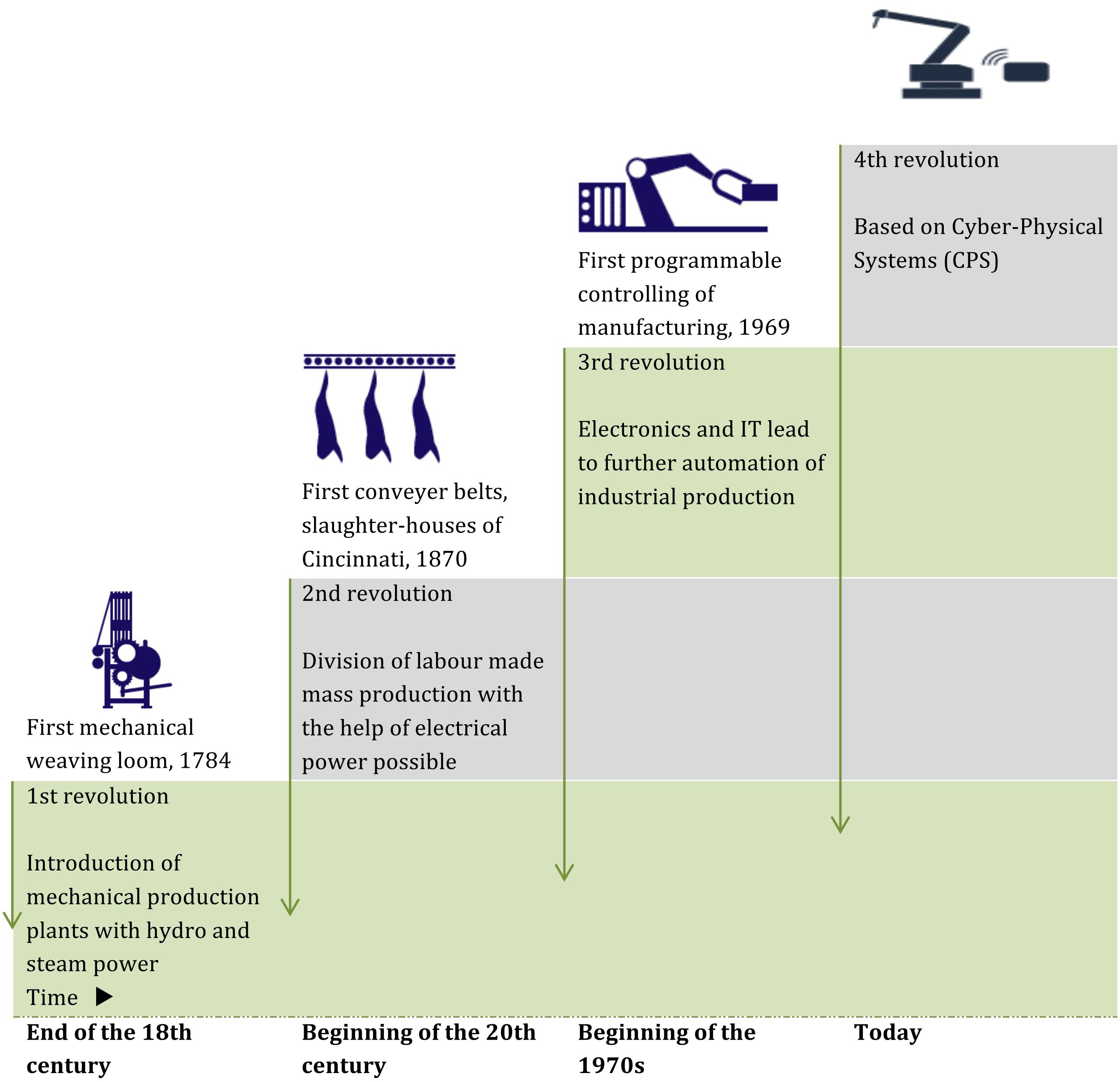
Digitalization and Industry 4.0 – a definition

Technological innovations have changed industrial manufacturing since the 1900s. And while this is nothing new, for the past years, digitalization has been widely discussed by companies and governments as the new transformation of manufacturing as we know it. More recently, the term Industry 4.0 or the Fourth Industrial Revolution has been used almost synonymously. Some of this terminology has its origins with the Deutsche Forschungszentrum für Künstliche Intelligenz (DFKI, or German Artificial Intelligence Research Institute) although it must be said that not everyone agrees with their analysis. However, the terminology has taken root even if definitions of these terms have remained fairly vague – they range from companies using the internet for customer-tailored solutions to indirect service providers via platform workers or crowd workers or the "gig economy", to the use of a wide range of technologies from 3D printing (additive manufacturing), to drones, to advanced robotics in manufacturing – and much more. Indeed, in addition to digitalization, electronic information and communications technologies, and 3D printing a more complete list of emerging science and engineering developments includes photonics, biotechnology, nanotechnology, microtechnology, advanced materials, and radical changes to energy and environmental technologies – and more. All of these are coming on-stream rapidly and will definitely have an impact - potentially a disruptive one – on traditional industrial manufacturing.

Industry 4.0 may not be the ideal term for the changes that are approaching, but given its widespread use, no substitute term is likely to gain traction. For the purposes of IndustriALL Global Union, Industry 4.0 is used as a label for the adoption of any of a range of emerging advanced and potentially disruptive technologies including, but not limited to, digitalization and artificial intelligence. Recent use of the term Industry 4.0 goes back to a research association of the German government and a High Tech Strategy Project under the same name led by the German Ministry for Research, but it has found more use in the English speaking world since then. In December 2015, the World Economic Forum had their meeting in Davos to discuss this issue, the Economist came out with a special issue about Industry 4.0, and Eurofound, a research branch of the European Union, has produced several reports on the future of work touching on some of the consequences of Industry 4.0 on workers. The most common summary probably stems from the German Artificial Intelligence Research Institute (figure 1).

Obviously, there is always an interaction between technology, business interests, and social structures. However, it should not be assumed that it is always technology that drives change in a unidirectional fashion; on the contrary it is the entire picture that should be examined. What social and economic environment is the technological change taking place within? What possible pressures could it exert on society, the economy, or the environment? Sustainability will result from integrative thinking.

Figure 1: The 4 Industrial Revolutions (source: German Artificial Intelligence Research Institute, translated)



(on the diagram, notice that the frequency and rapidity of transformative industrial revolutions could be increasing: for example 1st revolution 1750-1900, 2nd 1900-1970, 3rd 1970-2005, 4th 2005-)

New developments in technology have sparked industrial revolutions of varying durations throughout the centuries, with important responses from workers and their spokespersons each time. While previous industrial revolutions have ultimately led to increases in employment, which may not be the result this time. Indeed, previous industrial revolutions have even given rise to alternative economic and political theories (for example, communism) and social structures (for example, the welfare state). This discussion paper focuses here not only on digitalization generally, but on any industrial innovations and inventions that have the potential to radically change either production or product, and more importantly workers' circumstances and industrial work and manufacturing in general. The consequences of Industry 4.0 and its resulting transformation of our economy are so various that for the sake of discussing potential threats, benefits and solutions, a focus on industrial manufacturing (and its value chain) is important. This is also what makes Industry 4.0 a useful term and a basis of discussion for industrial unions.

Changes in industrial production, new technologies and their impact on workers and work are nothing new – the introduction of the steam engine that started industrial manufacturing in the first revolution, conveyer belts and assembly lines in the second, and the introduction of computers and electronics into production control in the third have shown this repeatedly – and trade unions have had to deal with these over past decades and centuries. What makes the Fourth Industrial Revolution different, is the speed at which it may exert its potential for significant and lasting impact on the economy, on disparities between the developing and the developed world, on the workforce, on the pricing of products and on our societies. Potentially, when the process of automation itself becomes automated thanks to technologies like artificial intelligence, there will be an acceleration of change unlike anything yet witnessed.

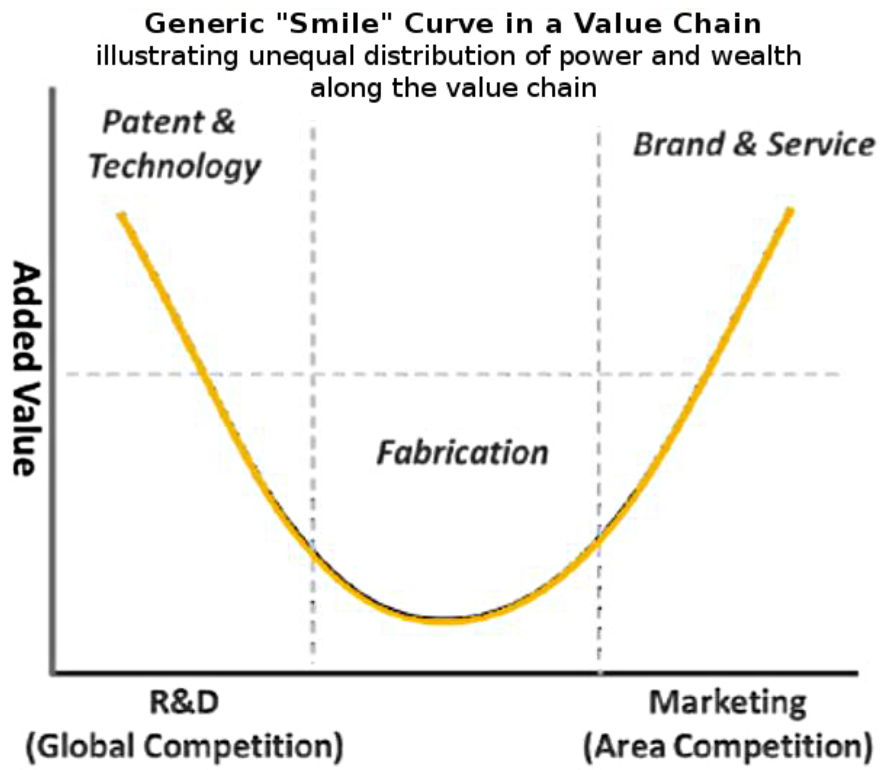
Thus far the discussions have been led by businesses and governments. However, the existing discussions seem to take a rather economy- and technology-centered approach; ignoring or treating very lightly the social impacts. Governments – especially in Europe – are investing in research and pilot projects for production processes using Industry 4.0 technologies (effectively subsidizing private companies). However, an analysis of the societal impacts – both threats and opportunities – the future of work, the changes in the labour market, and the potential strains on welfare systems and the existing economic disparities, seem to be either pushed back or neglected completely in the discussions. Rather than simply waiting for the social impacts we should be engaged in shaping those impacts. If we are to avoid the pitfalls of previous iterations of capitalist change, we need to insist that technology be human-centred; i.e. that any new technologies introduced have humans at their centre as active operators and decision makers, not simply as machine-minders and feeders of materials. Social impacts can and must be factored into any new system.

Some jobs will be transformed; some will disappear; some will be created. Companies that do not adapt may go out of business or be forced to merge with others. New companies will arise. Some governments will play a role; other will not, and where governments do intervene it has so far been to subsidize research and development, or education and training, without demanding job guarantees in return. While all of these things are constantly in play in our global economy, the changes implied by Industry 4.0 are likely to be radically faster than anything yet experienced.

Of course, subsidizing and cheering for the digital transformation must not be the only role of government. Governments must create and enforce laws, standards, and public policies, in the public interest, in this rapidly changing area.

Some of the dangers of digitalisation, and Industry 4.0, have been analyzed by IndustriAll European Trade Union (position paper 2015-2) as follows. The process of digitalisation “concentrates power and wealth in digital marketplace platforms, thereby depriving all other companies along the value chain with the capacity to invest, to innovate and to provide good wages and working conditions; it challenges the foundations of the permanent, full-time employment relationship based on collective agreements, because all functions of this relationship (including the control of the task) can be performed individually, automatically and remotely (and) consequently workers are placed in a world-wide competition on price, and precarious work with individualised terms and conditions is exploding (freelancers, bogus self-employment, crowd- or platform- or gig- workers), (and) it opens up unprecedented possibilities for asymmetric vertical and unilateral control over workers, but also of symmetric, horizontal, multilateral and democratic cooperation between them." IndustriALL Europe further states its belief that the technological developments are not deterministic, but with the correct policies and actions can be bent towards the creation of better workplaces and better jobs.

Figure 2: The following "smile" graph illustrates how the manufacturing step has been under-rewarded compared to other stages in the value chain. This is the result of both public and private policies rather than a law of nature; and therefore could in principle be changed.



Predictions about Industry 4.0 and its potential impacts on the labour markets seem to be significantly polarized and range from optimistic expectations of an increased number of high paying jobs to rather dark prognoses of job losses of up to 35 to 40 per cent. Even allowing for a gap between theory and (future) reality, it is surprising that the predictions for an industrial transformation that is already happening around us seem to be as unreliable as a crystal ball. The general consequences of Industry 4.0 are in some ways predictable, but numbers in this scenario are hard to provide: the performance of the economy as a whole, government spending on research and development and on qualification and education all play into these predictions. Different industrial sectors will be affected by Industry 4.0 and potential automation very differently. Product complexity, prices and existing qualifications of the workforce in the industry are indicators that can help to predict the consequences for the workforce and the way we see work in the future as a whole. This paper is meant to shed some light onto the different outcomes of Industry 4.0 so that we may prepare for the future trends in industries and sectors important to IndustriALL Global Union.

Three degrees of digitalized manufacturing.

The short, medium and long-term effects of the digitalization of manufacturing, Industry 4.0, are not entirely clear but will certainly vary greatly depending on different industries and the degree to which factories are able to apply modern technologies. In general, one can identify three different degrees: (1) Assistance Systems; (2) Cyber-physical Systems; and (3) Artificial Intelligence. These forms of technologies could be adopted separately or simultaneously, in a given workplace.

Assistance Systems are the least sophisticated level of digitalization in factories. These are computer-aided systems, mostly used in the assembly of products that lead workers through their required tasks step by step. Some prognoses expect that productivity, and thus revenues using these technologies will go up significantly with a simultaneous workforce downsizing of up to 25 per cent.

Cyber-Physical Systems, is a term that is broader than, but related to, the so-called Internet of Things. For the purposes of this paper it refers to a smart factory where machines are interconnected, sometimes self-operating and where the production progress of any part can be monitored at any time. This requires machines to be embedded into a network. Components are equipped with radio-frequency identification (RFID) chips that not only report information about the production progress to maintenance departments, process control panels and sometimes even the customer, but also send signals to the machine telling it what the final product is supposed be and what production steps need to be taken until then. Adidas has recently announced their plans for digitalized manufacturing and one of the main attractions of this for the customer is that this technology allows for customization: The customer can select colors, finishes or fabrics for the product that are then saved onto the RFID chip and automatically tell the machine which raw materials or parts to use during production. As an example, for the US economy, researchers expect a workforce downsizing in manufacturing as a whole due to smart factories of up to 35 per cent, but these prognoses are fairly vague on what predictive indicators are used and how the downsizing varies depending on the existing skills and qualification of the workforce and sectors. And while this technology makes customized, small volume production possible at a moderately low price, RFID chips are (at least as of 2017) ranging in price from between 12 and 25 cents (U.S.) a piece and will hence mostly be used in higher priced and high value added products. Their use in low tech and low priced mass production would require the chips to drop to under five cents apiece in order for them to be economical. Smart machinery that is not only able to read these RFID codes but also compatible with a factory-wide network embedded in an Internet of Things are a costly investment as well, which cannot be undertaken by all companies. Small and medium enterprises (SMEs) are most likely not able to make these investments without subsidies or other kind of public support. However, prices in new technologies are expected to drop significantly in the future and recent technological progress has developed an intermediary approach: electronic bridges that connect existing machines with each other; and while the machines themselves are not able to send progress reports to the control panel, the bridges are interconnected and replace this missing feature in the machines. This technology has the potential of keeping SMEs and their imminent innovations competitive with large multinationals that are able to make the transition to full smart manufacturing. According to the German Artificial Intelligence Institute, electronic bridges have the advantage to companies to up their returns and could mean workforce reductions of up to 10 per cent, since most tasks still need workers in order to operate the machines. Most of these rationalizations will occur in maintenance jobs since the electronic bridges will pick up problems as soon as they occur and could allow maintenance to be managed on-demand.

Artificial Intelligence is the most sophisticated, technology-wise, level of digitalized manufacturing and also the most controversial. And not just manufacturing: artificial intelligence is being applied to white-collar jobs, for example in sorting orders, processing customer data, selecting applicants for positions and in the processing and analysis of “big data”. The discussion about this and its use and impact on economy and workforce seems fairly divided. For some, this is still a product of fantasy that is by far not yet ready for commercial use, for others it is an already evident fact that is expected to transform production rapidly. First, however, one has to clarify that artificial intelligence is not equal to advanced robotics – it will control and enhance advanced robotics, among other things. The idea of artificial intelligence is, in a way, similar to that of smart manufacturing, where machines – robots, in this case – are able to communicate with and respond to each other, but instead of reporting to a central control panel that is operated by highly skilled workers, the machines are able to operate fully independently. And while research on this issue is progressing and it is progressing fast, the technology is still so expensive that its use in manufacturing will likely be delayed and, once in use, will first affect high-tech and high value-added industries that can recover the large initial investment over a relatively short time. Nonetheless, even though not quite as prominent in manufacturing so far, this has potentially the strongest impact on industrial labour, possibly even making many present-day workers obsolete. It will be necessary to examine what work humans can do better than artificially intelligent robots.

These degrees of digitalization of industrial manufacturing mark path dependencies that vary significantly between industrial sectors, and between regions within the same sector – and not just industrial manufacturing in its strictest sense but also the related white-collar, and service-sector workers. Furthermore they may change over the short, medium, and long term as the tasks within each sector evolve. However, there are common characteristics amongst them that will redefine work the way we know it. Intercommunication is the common denominator in all of these cases: Machine-to-machine and machine-to-human communication will increase in smart manufacturing. The quality and quantity of data will increase – with clear benefits for the manufacturer and the consumer (i.e. monitoring the production progress of a custom product similar to the way that we track the delivery of our Amazon order today; and better ability to predict future production needs), but this also means that workers and workers' productivity can be closely and precisely monitored. Trade unions must refuse such personal data monitoring by employers because it can only lead to a cannibalistic competition among workers, undermining solidarity. How will workers compete when their work is measured against that of a machine? How will productivity be measured when an individual's work is performed in the context of a complex technical system that must only be kept running, and there is no longer a clear relationship between hours worked and production? What becomes of our expectations of minimal privacy, even at work?

We must ensure that personal data remains safe. Big Data is a term for the collection and analysis of data sets that until now have been too large or complex to be useful, but with ever more powerful computers, clever and complex algorithms and sophisticated software, have become a common management tool for many corporations. With any Big Data system comes also the threat of the data being stolen and hacked. Who will be allowed to access and use the data? Whose data is it to begin with – the worker's or the company's? It is unlikely that workers will have much say on what information is collected about their performance or what is done with it.

Again, IndustriAll European Trade Union points out the need for open standards for the digital integration of manufacturing and data. If this is allowed to become a proprietary standard, too much wealth will be concentrated at one point in the value chain. Furthermore, digital platforms and "big data" must not become monopolies. Three principles should apply: (1) "big data" must be considered "open data"; (2) search algorithms must be open and fair; (3) cross-subsidisation structures and other unfair trade practices must be prevented, or where they already exist, broken up.

These three different forms of digitalized manufacturing: assistance systems; cyber-physical systems; and artificial intelligence, – all aspects of Industry 4.0 – will change work, they will affect developed and developing nations to differing extents and under different premises, they will set diverse requirements with regard to the qualifications of workers, they will impact workforce reductions to different extents. Beyond manufacturing, it is important to not overlook the impact of these technological changes on other areas of work. They will redefine our societies, challenge our social welfare systems, they could potentially worsen already existing societal inequalities – and yet, the discussion of these crucial societal aspects remains largely neglected. Once again, it falls to the labour movement to make the social case.

Industry 4.0 and sustainability

Digitalization of industrial manufacturing not only has benefits for companies and governments from an economic perspective, it may also have clear advantages with regard to environmental sustainability. Digitalized production allows companies to make efficient use of raw materials, and by using RFID chips to save the information about product assembly regarding which materials are used in which components. Thereby it also makes disassembly and recycling easier, and fewer resources are wasted. This is the basis of the so-called "circular economy", one of the key advantages from an environmental perspective and it is surely one that appeals to governments in particular.

The increased use of smaller-scale, local, and renewable energy production (for example, rooftop photovoltaic) accompanied by digitally monitored energy consumption and artificially intelligent energy management technologies may lead to the decentralization of energy production and eventually the energy grid itself. This is an already-existing trend: for example, many European paper industries already practice cogeneration, and it will be or is already reality for other sectors as well where plants have their own power plant. Exhaust heat can be transformed into usable energy using waste heat recovery systems; companies could increasingly rely on renewable energies such as solar, wind and water. Overproduction of energy in industrial plants, i.e. energy that exceeds what is needed for production, can be fed into the energy grid and be of use to communities. Multiple smaller-scale energy generation sites will imply changes to the energy grid which is presently engineered to accommodate a relatively small number of large-scale generators. Rethinking this to a future landscape in which generation sites are more widely distributed could significantly reduce energy wastage. With Industry 4.0 feeding into the emerging trend towards energy grid decentralization, there are researchers who see possible positive impacts on energy infrastructure in more precarious regions of the world like Africa. The availability of alternative energy sources could – by these predictions – not only improve people's lives, but also make it more attractive for companies to use regional human resources, bringing a boost to local economies as well. However many existing jobs in energy-generation centrals, or in electrical utilities, will be lost or transformed.

In opposition to this optimism, however, the increased potential for flexibility and rapid response to consumer wishes can accelerate product cycles and lead to increasingly rapid obsolescence of products. This would generate an increased demand for resources and an increased generation of waste. Also, the new digital technologies need additional resources themselves, e.g. rare earth metals for chips and other minerals for digital equipment.

While there are potential environmental advantages that come with Industry 4.0, at the same time this transformation also means potential social threats to workers, their families and their communities when their jobs are not secured during the transformation. Historically, no technologically induced economic transformation has ever been stopped, but trade unions must insist that workers' rights are enhanced by technological change, not diminished. We need to insist on fair work arrangements established by agreements in the workplace, by campaigning for laws which respect the role of workers and unions. Workers organisation must remain involved in the discussion when the fates of millions of workers worldwide are affected by decisions made by companies, and by governments who supply subsidies and invest in pilot projects. History has shown that industrial revolutions of this extent can only be mastered if workers' expertise and knowledge are taken into account – if they are neglected in the process rich sources of knowledge and future innovations are wasted. The disparities between developed and developing nations should particularly focus governments' attention on how this transformation may be managed in such a way as to prioritize the potential positive societal impacts and keep societal costs at a minimum.

1. Industry 4.0 in the Context of Global Development

The discussion about Industry 4.0 is so far mainly led by only a few countries and regions. Europe has perhaps had the most influence, both in academia as well as in politics; although other countries are working on similar strategies, e.g. "Made in China 2025". The "Europe 2020" strategy was launched in 2006 by the European Union and is aimed at "smart, sustainable and inclusive growth". And while this strategy is not just aimed at economic growth, but does actually take into consideration a large number of social factors and a necessary adaptation of EU and national policies on education and social welfare, European developed nations lead this discussion without paying much attention to the effects that this transformation may have on the developing world. Industry 4.0 must not be allowed to become just another way for developed countries to punish less-developed ones.

It is likely that in each sector the implementation of Industry 4.0 will start in those industries where the cost of doing so will be expected to most quickly be offset by the potential productivity – and hence profit – gains. The early adopters of these technologies will put pressure on their immediate suppliers and customers, and in turn their respective suppliers and customers and so on, both upwards and downwards through the full value chain, to follow suit. Competitors too, and their value chains, will feel the pressure to adopt the technologies of Industry 4.0. Therefore the growth in adoption will not be a gradual, or linear, process. Instead its spread will likely be exponential once it is fully underway, and given today's globalized value chains will not remain - in fact, is no longer – a European, or developed country, phenomenon for very long. The present shape and direction of global supply chains and labour force mobility will re-align.

Industry 4.0 will change more than just production methods. It will shift the point of greatest value-added along the value chain. The design, engineering and maintenance stages of a product must be considered, not merely the industrial production of it. It may force a re-thinking of intellectual property rights – patents and copyrights - and the rights to so-called "big data". Existing laws in this area have allowed an extreme concentration of wealth by a handful of companies.

1.1 Looking past the European Economy – threats for developing nations.

The way that developed nations act in this transformation, the way governments decide to subsidize this socio-economic change or generate support through other means (i.e. tax cuts), has a strong and very direct impact on developing nations. For the latter, low wages are one of the main competitive advantages over developed countries in a globalized economy. This has led to the phenomenon of de-industrialization in some developed countries, although a better term would be industrial displacement. And while precarious work is particularly prevalent in Third World countries, many workers, their families and communities depend on the (small) incomes they can make from this industrial labour, even if sometimes it makes for a barely livable wage and fails to cover the basic needs.

Industry 4.0, however, makes production of specialized products in small numbers possible at relatively low prices – even in the developed world. Resources and materials are being used more efficiently and can be reused and recycled better, the decentralization of energy generation and the distribution grid allows companies to self-supply their energy and even have an extra source of income when they are able to sell energy that is surplus to their needs back into the energy grid, supplying communities with energy. And of course, rationalizations and workforce downsizing make production cheaper, too. This is a strong benefit for companies and some researchers see it as a powerful economic boost, especially for Europe: After all, the "Made in Europe" seal is associated high quality products which means that they will usually appeal well on the market.

So when the manufacturing of products in developed countries trends cheaper, developing nations begin to lose their competitive advantage on wages and are put in a direct competition with them – and workers will likely pay the price for that. The technologies surrounding Industry 4.0 – in this case mostly assistance systems and cyber physical systems – are still relatively pricey and, given the low wages in developing nations, will probably not be applied there any time soon. However, this means that workers in these countries are put under direct pressure when companies threaten to move production back into developed nations that offer digitalized manufacturing. Adidas is an excellent example for this: In the summer of 2016 they announced that they would be building a highly digitalized factory for high-end sneakers in Germany and thereby moving some of the production away from their current main production sites in Eastern Asia. The pressure on wages in Third World countries will increase, all while workers already face precarious work circumstances and barely livable wages. Not only that, the overall pressure on workers could rise in areas such as working hours, occupational health and safety, etc.

While Industry 4.0 technologies so far are still relatively pricey, once the prices of advanced robotics outweigh the cost of workers' labour, workforce downsizing even in the developing world is a large risk. If following a rational choice approach, one would assume that within Third World countries, those with the highest wages would experience workforce downsizing and automation through advanced robotics first. However, the prominent example of Chinese iPhone manufacturer Foxconn proves otherwise. China has neither the highest, nor the lowest wages in Asia. However Foxconn has already made significant investments in their so-called Foxbot which has since been able to replace around 30 per cent of their work force – in total, some 300,000 workers. Digitalization impacts on developing countries might at first seem indirect. However this shows that developed countries may corner them into a competition they simply cannot match sustainably. Therefore they are not safe from the negative direct consequences of Industry 4.0 on workers after all – they might just be delayed. In fact, developing countries will be hit much harder, not only because of the already existing problems of low wages, little to no health support, precarious work situations, but also because of weak social welfare systems, particularly in countries where informal and irregular work is common, which put workers and their families at higher risk of free-falling if they are in fact affected by rationalizations through automation.

Finally, the intent and impact of trade rules and agreements must be understood. It is an emerging trend to give the digital economy special status within trade agreements. This will make it more difficult for future governments to control monopoly power and undue concentration of wealth. Other policy tendencies include increased patent and copyright protection (intellectual property) and barriers to the control of data or privacy where the data is stored in another country. These could become serious obstacles to meeting the Sustainable Development Goals (see 1.2, below). Offshoring of production digitally controlled from a remote location, or alternatively local production using 3D printing technology using software and templates that are protected intellectual property, are other new areas that are not well understood yet.

Note that the terms “developed” and “developing” are not absolute. There is a range of levels of economic development, with reliance on the exploitation of raw materials and industrial production that (in many regions) has not yet fully incorporated the benefits and lessons of previous industrial revolutions. What is clear, is that there must be a pathway to a better future, for all. The benefits of Industry 4.0 must be shared both within, and between, nations.

Actions of governments and companies in the developed world, and in particular in Europe, directly impact the developing world and should be taken into account during the decision making process on Industry 4.0 in the developed nations.

1.2 Sustainable Development Goals – Implications for Industry 4.0.

In 2015, the United Nations announced their Sustainable Development Goals (SDGs) (figure 3) in continuation of the Millennium Development Goals (MDG) established in 2000. Clearly, developed nations ought to follow a certain commitment to sustainability also with regard to Industry 4.0.

Nearly all of these goals have clear implications to making sure that the coming industrial transformation is done sustainably. SDG Goals #1, #2, and #3, together with #8, also imply generating sustainable employment with a livable wage, banning precarious work and improving occupational health and safety. Building up industry, innovation and infrastructure (#9) is an issue not just for developed nations, but also for Third World countries and has high relevance in the context of the digitalization of manufacturing. Industry 4.0 comes with a variety of new challenges and requirements for the qualifications of workers. The better the educational systems, the better they will be able to adapt to the new changes in industry and – in turn – make for less systemic inequalities (#4, #5 and #10).

The most important SDG is probably #17, because it actually states the necessity for global cooperation and partnership in order to achieve these goals. To make Industry 4.0 an industrial transformation that makes use of the benefits and keeps threats to a minimum, an equal amount of partnership is needed in this context as well.

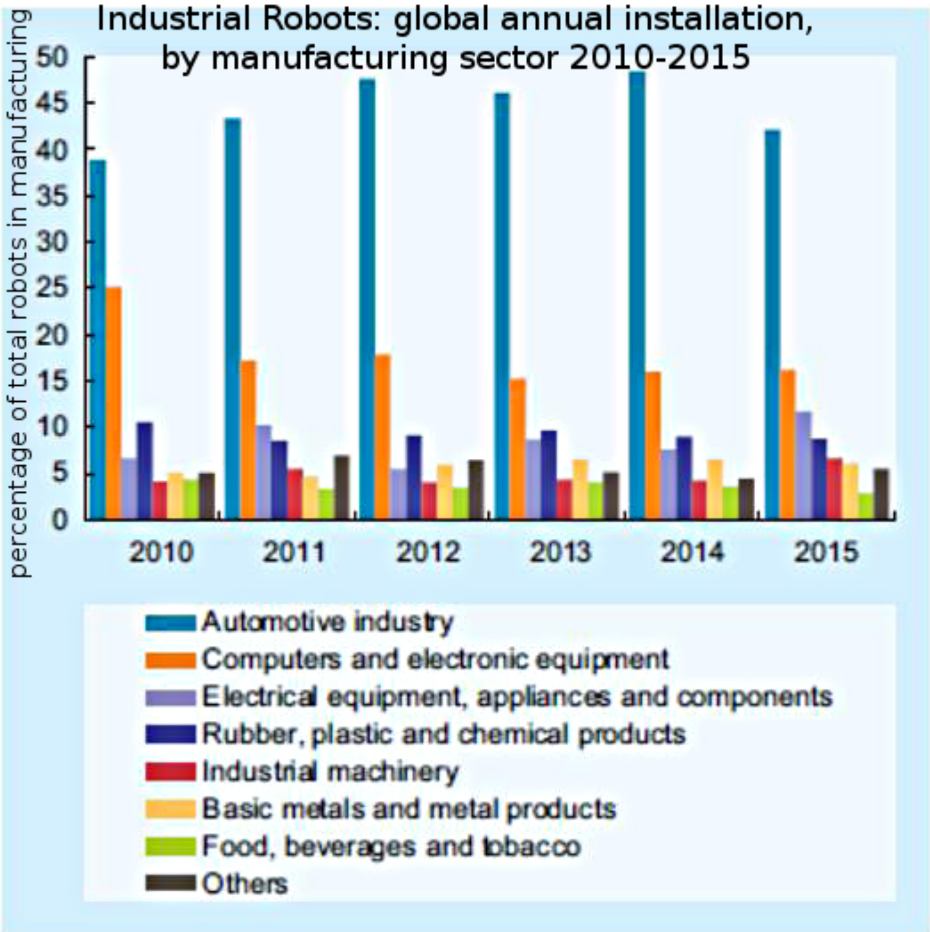
One of the potential positives of the digital transformation is the possibility to obtain, or require, detailed information concerning the full value chain of a product – where it is manufactured, how, and under what conditions. This kind of digital signature would enable the promise of corporate social responsibility to become a reality.

Figure 3: Summary of the UN's Sustainable Development Goals until 2030, adopted in December 2015 (source: www.un.org)

What remains clear is that Industry 4.0 is a global phenomenon, in which countries cannot and should not just consider their national economies, but also tackle this problem globally. There are indeed many opportunities that come with this transformation, but workers cannot be the ones to pay for this transformation by being pressured into accepting lower wages, continuing precarious working conditions, competing against machines in productivity and by possibly losing their jobs. On the other hand, such opportunities as Industry 4.0 may create will only be available to workers if they are able to obtain training, education – and qualifications – in those areas and skills that will be in demand. Trade unions are more important than ever in the context of this transformation.

2. Human Resources in Times of Industrial Transformation

The prognoses for future skill requirements in manufacturing vary greatly – some say they will rise and the most needed skill will be programming and IT, others say that workers will mostly be needed in controlling jobs and, supposedly, the necessary qualifications for these jobs will in fact decrease. In some industries we notice the trend of merging of sub-segments of industrial production (sales, design, creation, production and maintenance) into a "full-service", highly- and multi-skilled workforce. In others, we have seen a de-skilling take place as robots take over most roles, leaving menial but non-repetitive (and therefore difficult to automate) work for humans (figure 4). These varied predictions are due to three main reasons. Firstly, industrial sectors vary largely with regard to these skill requirements and therefore need to be analyzed separately. Secondly, regional variations have a large impact on results of these prognoses (Europe may have different results from the US, Eastern Asia will vary from South America, etc.). Thirdly, qualification requirements vary with the degree of digitalization. The use of new technologies in manufacturing means that workers face varied challenges and new requirements. *Figure 4:*



2.1 Smart manufacturing – highly skilled workers combining practical and IT knowledge

"Smart manufacturing" takes highly skilled workers to a completely new level. Clearly, any worker operating in a smart factory is required to have an understanding of practical as well as engineering and programming skills. Overall, qualifications required of workers in an industrial plant are likely to rise. Maintenance work on the other hand, while requiring high skill levels, will mostly be outsourced or kept "captive" by machinery manufacturers as they move to a model of selling the services of their machinery rather than the equipment itself (raising important questions e.g. about the continuing failure to transfer technology to the developing world). Despite this it means, on balance, that countries that already have a highly skilled workforce on average will be able to adapt to these changes easier than those with more medium and low skilled labour force. However, this does not protect them against rationalizations when there is less need for human labour in manufacturing. This is discussed rather controversially, by Ben Shneiderman, a professor for computer sciences at University of Maryland who wrote that:

"Robots and AI make compelling stories for journalists, but they are a false vision of the major economic changes. Journalists lost their jobs because of changes to advertising, professors are threatened by Massive Open Online Courses (MOOCs), and store salespeople are losing jobs to Internet sales people. Improved user interfaces, electronic delivery (videos, music, etc.), and more self-reliant customers reduce job needs. At the same time someone is building new websites, managing corporate social media plans, creating new products, etc. Improved user interfaces, novel services, and fresh ideas will create more jobs."

In a study conducted by the Wolter et al, for the German Institute of the Federal Agency of Employment (2016) it is predicted that as demand increases for digital technologies, so too will the need for investment in education and training. The study predicts that 1,540,000 jobs will be lost by 2025, while 1,510,000 jobs will be created. Given Germany's previous success in adapting to e.g. the closing of coal mines, these prognoses claim that the total of some 30,000 workers that would be out of jobs could be absorbed into the system fairly easily. And while there might even be some truth to both of these statements – Ben Shneiderman's and the numbers in the prognosis about Germany – one thing remains clear: The jobs lost and the jobs created have very different profiles and requirements that require intense additional education and training and cannot be matched ad hoc. Neither is there a guarantee that any new jobs created will be accessible to displaced present-day workers for other reasons – for example, they may be in entirely different regions.

The transition to smart manufacturing has a variety of impacts on how work can and will be done in the future and on its inclusiveness, or rather exclusiveness, for some workers. Manual work is decreasing, while computerized work is in fact increasing. Computer literacy and being able to understand and work in common programming languages will be a valuable skill in the future. Both of these skills require extensive education, training and professional development and means that some parts of society might be left behind. Languages, be they natural or programming languages are best and easiest learned at a young age, meaning that older generations of workers might have a harder time achieving the necessary qualifications. Migrant workers whose first language is not English may have an unequal start in training (although some studies have shown that they are not greatly disadvantaged because of the extremely logical nature of programming languages).

Education and training requires time and effort outside of the regular work schedule, which has been estimated by the European Union to mean at least 40 hours per year in some occupations – while the present-day average is around 9 hours per year. This likely means workers with children, and in particular women, will have larger issues in matching their work requirements and family duties. Workers with disabilities, especially those who are mentally impaired, have thus far been able to be included in some of the easier tasks in manufacturing plants – but with the rising complexity of tasks and the necessity for computer and programming skills, these jobs are also becoming more exclusive.

The profile of the new knowledge worker, which has been described as the "blue collar innovator", or the "innovation worker" is someone who has gone through years of education and training, who is – if not proficient in – at least able to understand major programming and coding languages. Most will agree that in order to get to this kind of labour force, advanced education and training needs to be offered to workers. This needs to be done in a way that respects worker's choices, is inclusive and that doesn't aggravate already existing social inequalities.

In contrast to smart manufacturing, the skills required for industries using assistance systems are very different. Computer programs will assist during assembly of products and will give relatively clear instructions to the worker for the tasks she or he is required to do. The profile of a worker in this scenario is hence very unlike the knowledge worker. Manual skills are in fact more important in this case and programming skills are not necessary for this work. Especially in emerging economies with a medium skilled workforce this transformation could actually be an attractive opportunity and appeal to companies because of the already medium skilled workforce present, and could be a boost to their national economies.

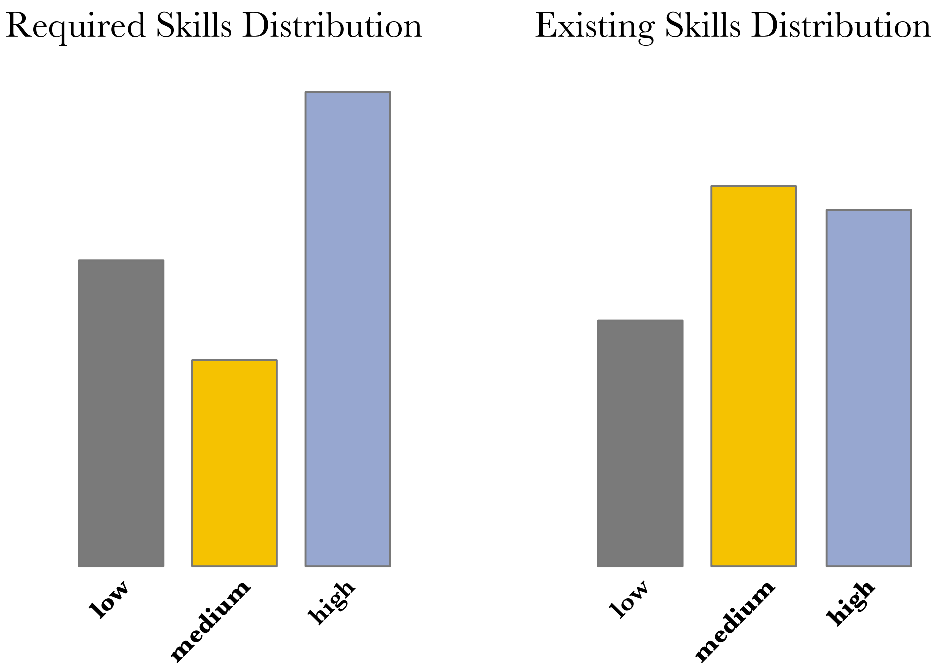
2.2 Skills gaps and skills misfit

It is not the case the today's workers lack skills, but the skills they possess may not be the skills in demand in new workplaces. Qualifications are – and this is commonly agreed – one of the most prominent challenges when it comes to Industry 4.0. The changes in the required skills are not just a challenge for workers, but they also have strong impacts on societies, especially in developed countries where skills gaps and skills misfit are already common problems in the labour market (see figure 5).

To further complicate the problem, the aging workforce – a demographic phenomenon felt most strongly in Japan, European countries, Canada and Australia – means that an education and training strategy in those regions must take into account the strengths and weaknesses of older workers to be successful. Geography, migration, and urbanization must also be taken into account when planning to make education and training accessible to those who need it. In the context of accessibility to education and training, it must be pointed out that trade unions have historically been among the most effective delivery agencies for occupational training. Are we ready to take on this role in the advanced-technology fields? Italian trade unions, for example, have proposed the establishment of "Competence Centers" or centers of excellence to facilitate the acquisition and delivery of skills; not necessarily within the existing university framework.

Generally speaking, in most developed economies, industrial design and the manufacturing of high quality products require a large amount of highly qualified workers and engineers. At the same time there is a continuing need for private and personal services, such as cleaning, laundry, maintenance etc. that require lower skills. On the other hand, medium skills are required to a much lesser extent because a large share of medium skill manufacturing has relocated to other countries.

Figure 5: Model of required vs. existing skills distribution; developed country industrial labour markets. Source: Hilpert, Y, 2017.



The existing qualifications in Western societies differ greatly in distribution from those needed: Well established educational systems and apprenticeship programs mean that large shares of society have at least medium skills and a relatively small share of people has low skills. And while this might be a good sign for educational systems, it also points to a problem of supply and demand: The potential overproduction of a medium skilled workforce means that there could be a large share of this group struggling to find a job matching their qualifications – they are overqualified for the lower qualification jobs that are also paid less and hence not according to their personal qualifications; while they are not skilled enough to fill the skills shortage in the highest qualification jobs. With industrial work and design losing its appeal to younger generations in Western societies, the problem of a skills gap has arisen in the higher skilled jobs.

In response, both companies and governments in Europe have engaged in strategic skills planning and taken measures to make industrial jobs more appealing, i.e. by giving out specific scholarships for STEM subjects (Science, Technology, Engineering and Mathematics) and guaranteed job offers after successful apprenticeship programs. (A downside of this strategy is that it can be argued that in general companies are not doing their share and are instead relying on the public sector to subsidize their education and training needs.) There is clearly a technology focus in a variety of the policy making initiatives, especially in education policy – but in times where there will likely be less demand for human work in the future, new solutions for social issues should be a focus as well. The social sciences and liberal arts, in their role as possible social innovators, should get just as must political attention and investment as STEM subjects.

This demonstration shows several problems: The skills misfit not only means that a certain share of workers will be forced to work at jobs that actually do not match their own qualifications and that they are overqualified and underpaid for. It also means that a large share of existing human resources in society could remain unutilized, even though the average qualification is fairly high. How is this relevant in the context of Industry 4.0? Existing skills and qualifications in society as well as existing labour market issues such as skills shortages and misfit are important indicators for how Industry 4.0 is going to affect society. Demand for workers with low educational qualifications will probably remain stagnant in developed countries: low qualification manufacturing is cheaper in developing countries and has often already relocated; low qualification services are often personal services such as cleaning, caregiving, maintenance and gastronomy that cannot be as easily outsourced or relocated. Medium skill manufacturing jobs, however, are prone to being digitalized, thereby being at higher risk for workforce downsizing and rationalization. Medium skilled services (web design, calculations, etc.) can easily be outsourced and provided from anywhere around the world for a fraction of the price via various platforms and will therefore also shrink local job opportunities in the developed world for that sector. This means that there will be an even smaller share of medium skill jobs for the relatively large share of workers with these skills. Some high skilled manufacturing can be done through smart manufacturing in the future which will mean job cuts, while some may be enhanced by assistance systems and the latter could actually generate jobs. Whether existing workers with medium qualifications will be able to access those jobs will depend on the availability and utilization of education and training programmes.

Even highly skilled workers such as technicians and engineers face a situation where their education and skills may become obsolete and out of demand, if not continuously updated.

Some remarks on skills and the regional divide (see bubble analysis, figure 6): as mentioned before, product complexity and skill level are important indicators for the economic developments of Industry 4.0. Each sector has different characteristics that make it more or less prone to changes, especially with regard to job losses or gains in this context. There has been a resulting shift in the type of jobs as well, with relative higher demand for engineers, technicians, salespeople and service providers; and relatively lower demand for predominantly manual workers. Trade unions who are not open to these new employees' groups will become obsolete.

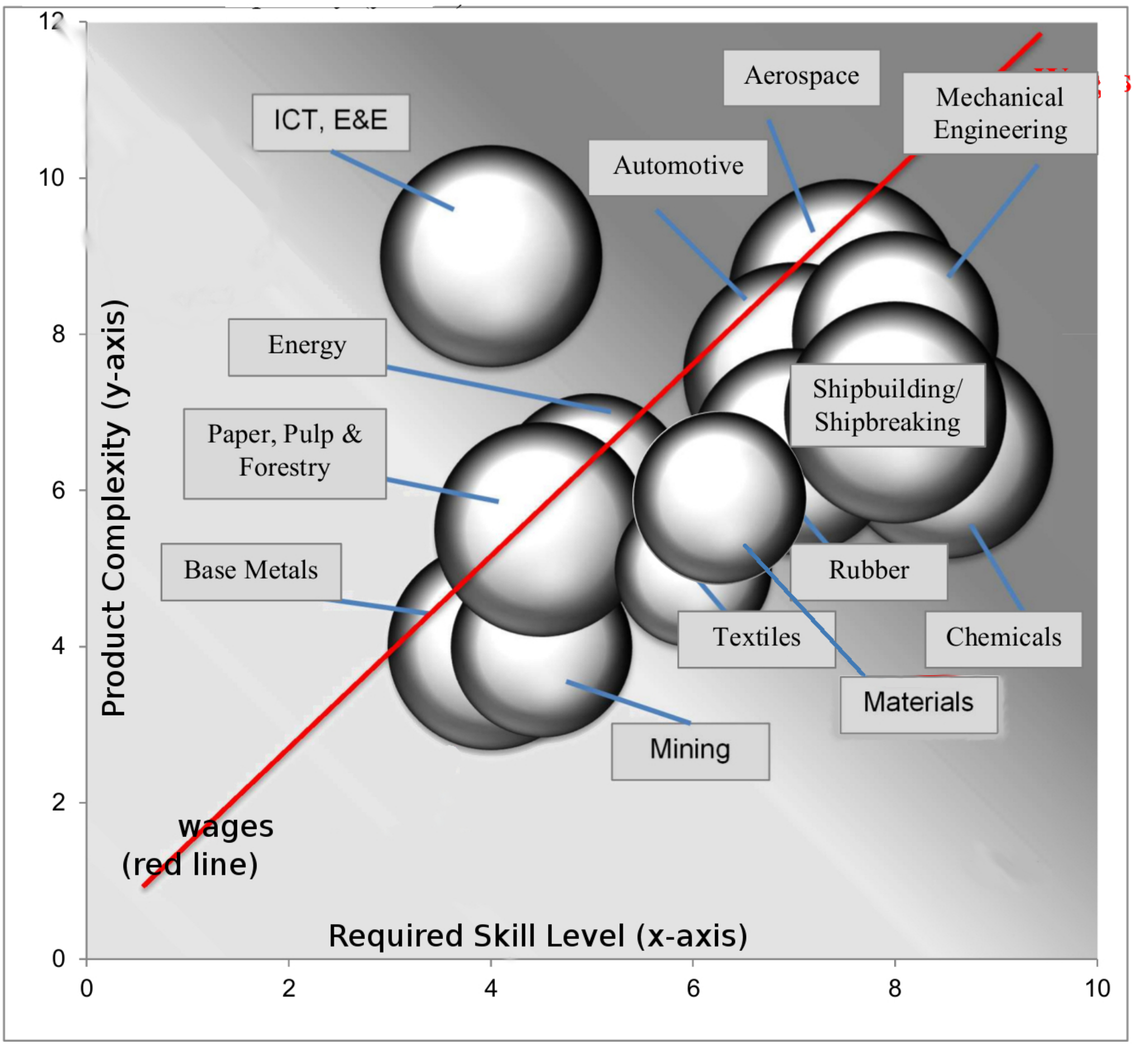


Figure 6: Qualitative model of IndustriALL's industrial sectors on a plot of product complexity and required skill level. The background shading corresponds to the regional divide (light grey = developing world, dark grey = developed world; size of bubble indicates relative number of workers affected). Adapted from Hilpert, Y: 2017.

3. Sectoral Variations for Industry 4.0

The consequences of Industry 4.0 depend on a variety of different indicators, some of which have already been discussed in this paper: Industry 4.0 will affect various industrial sectors and global regions differently and will likely reinforce already existing inequalities both within and between regions.

Additionally, product complexity and pricing, the required skill level and the pre-existing level of automation are important indicators, because they allow for predictions with regard to governments' and companies' behavior in this transition: Where the initial capital investment is too high to be rewarded by revenues soon enough, companies will likely not invest in the new technology. Similarly, if they are lacking the qualified personnel to work with these technologies, their investment may fail as well.

IndustriALL's objectives are to ensure that Industry 4.0 is used to develop cooperative, integrative, democratic and egalitarian workplaces and societies – with new and better industrial jobs. This will require strong action on the part of the trade union movement.

When looking at IndustriALL's industrial sectors we can group them into roughly three groups: low-, medium- and high-impact; according to how strongly they will be affected by Industry 4.0 in the immediate to near future.

3.1 Low immediate impact of Industry 4.0 – heavy industries, intensive manual labour: Particular Impacts in Base Metals, Mining, and Textile Garments and Leather

Base Metals

Industrial sectors like base metals are likely not going to experience a large transformation from Industry 4.0, in the short term. Many jobs in this sector require a combination of relatively high skills and relative high labour intensity and are so far not particularly easily automated even with advanced robotics, which would make the initial investment for companies high and uneconomical.

That does not mean there will be no transformation, however. The steel industry is still regarded by many as a massive job-creator, but that is changing. In the medium to long term, certain parts of the production process may be outsourced or digitalized and even more of the process will be controlled from central control rooms than on the plant floor. Process control computers will make more of the decisions than they already do, for example on the precise blends of raw materials, while machinery will increasingly be self-diagnosing with respect to maintenance needs. Maintenance might become digitally managed, and ultimately outsourced to service providers specializing in specific platforms. Leasing, rather than buying, production equipment will have the same effect: the equipment supplier will retain responsibilities for maintenance and be informed on the need for it by digital ICT built into the machinery. Further technological achievements in self-driving cars may be an attractive feature for logistics in these sectors – if not throughout transport and delivery, then at least in material handling within the plant itself. In the longer term, of course, even the jobs that are not presently economical to automate will be transformed.

The German research institute Fraunhofer IAIS distinguishes between digital integration within the mill, in terms of optimizing production on the one hand; and digital integration involving entities external to the mill, from suppliers to customers, on the other hand. The first tends to enhance efficiency, productivity, and quality while the second will involve flexibility, customization, inventory and logistics.

The speed of that transformation will vary considerably, but is already underway in some areas. At Voestalpine AG's new rolling mill in Donawitz, Austria, just 14 workers are needed to produce the same amount of product as about 1,000 would have in the 1960s. This is due to advanced automation and centralized process control. Not counting maintenance and logistics jobs (of which about 300 still exist at the plant), the remaining few production jobs are white-collar control-room technicians. Globally, producing one ton of steel now averages 250 worker-hours compared to 700 worker-hours, 20 years ago – and this decline not only has not stopped but may accelerate.

Blast furnaces, by the nature of the work, may be less amenable in the short term to this kind of radical automation than a rolling mill, but change is coming there as well. Voestalpine is already looking at modernizing these and eliminating many existing jobs.

Mining Sector

The mining sector is relatively diverse with regard to the existing technological progress used on site. Some mines still require a large amount of manual labour while others are in fact already heavily automated, which would imply that the mining sector includes good candidates for stronger industrial digitalization. Although the digital transformation, or spread of these technologies, is dependent on the regional situation, the "digital mine" is not far off the horizon.

Where wages are cheap and currently used technologies are low, companies will likely not invest into digitalizing mines in the near term because the revenue return from this investment would remain fairly low. However, there are examples already of mines where robots or remotely-guided machinery do a great deal of the work that would formerly have been done by human beings working at the rock-face; drilling is another such example.

As the cost of these technologies decline, increasing utilisation of these technologies should be expected and the accessibility of advanced technologies including sensors, analysers and connectivity of production machinery – will put mining's internet of things (IoT) and cloud-based services at the centre of the mining industry's digital space (see figure 7).

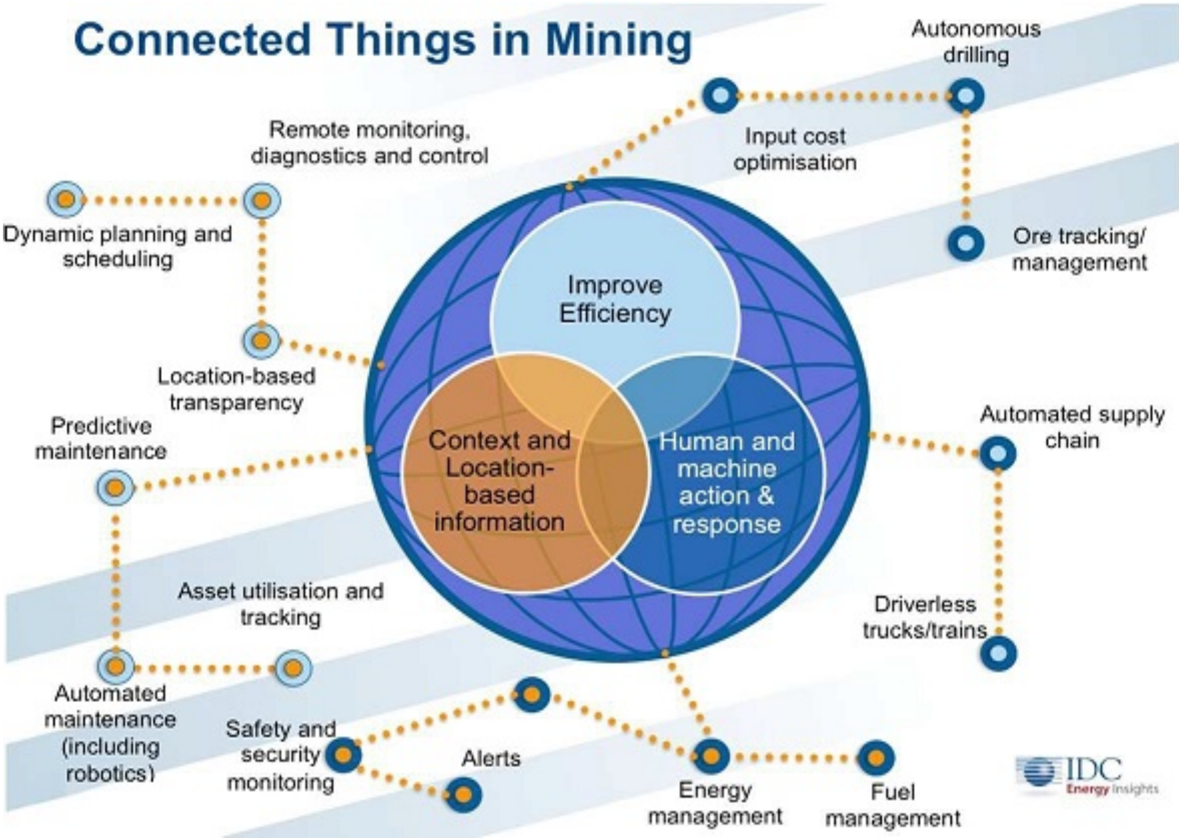


Figure 7: "The forces powering the rise of the "digital mine" are as compelling as those driving change in other industries" - Marcelo Sávio, IBM global industry solutions architect.

The driving forces behind the rise of the "digital mine": what Marcelo Sávio calls , the "changed economics" of mining; are productivity, technical and social challenges, rising input costs, fallen (falling) commodity prices and safety imperatives.

The numbers driving digitalization are staggering. According to the International Data Corporation (IDC) Energy Insights' **Digital Transformation in Mining Webinar: Driving Productivity Improvements**:

- 28% of mining companies globally expect their IT budgets to increase despite current industry challenges.
- Technology is playing an increasingly critical role for investments with 70% of miners are looking at mine automation investments, 69% plan to look at centralized command and control and more than a quarter of miners are looking at the role robotics can play. Those companies that can create competitive differentiation will be in the best position to perform now and when commodity prices improve.
- Mining companies will increasingly create visibility, responsiveness and control through data insights. There is projected to be a 30% increase in the mining companies utilizing advanced analytics within operations in the next few years, particularly in energy, ore and supply chain management.

The impact on jobs is obvious as is the need for a different skills set. Just Transition measures – programmes to keep affected workers whole – as a policy response will need to be complimented by national governments' responses towards consideration of economic diversification projects. Diversification of local economies would be strengthened by an integrated development economic model - a Sustainable Industrial Policy - that will require mining companies' infrastructure development plans to be integrated within local economic development plans. These have so far been utilized where the investment can be justified for exceptional circumstances, such as the mining of very high-grade uranium ore that human workers could not do safely due to the radiation hazard. The point being made is that the technologies to replace many mining jobs with robots, exist. As the cost of these technologies declines increasing utilisation of these technologies should be expected.

Textiles Garments and Leather Sector

The textiles, garments and leather sector is also relatively diverse with regard to the products and the technologies used. Fibres and textiles used in the manufacturing of specialty materials like carbon fibre reinforced fabrics and plastics, increasingly used for cars and airplanes and other uses, already use quite modern machinery. On the other hand, garments and leather still profit from low wages and are manufactured under extremely precarious, unhealthy and unsafe working conditions, typically in the developing world. This sector will likely be partially affected by Industry 4.0: special textiles that are already using high technology machinery could be further digitalized.

Until recently, the automation of garment manufacture has been considered a very difficult task because of the flexible and stretchy characteristics of fabrics, the need for an ability to customize products, and other variables. However, there have been advances in the field and robots are now available that can perform the work of human sewing machine operators. As this technology is proven, hundreds of thousands – or perhaps even millions – of sewing machine operator jobs could be at risk. As this is a key industrial sector in some developing countries, the social and development risks cannot be overstated. Indeed, the potential for automation to be cost-effective even in low-wage regions raises important questions. Will initiatives like ACT (Action, Collaboration, Transformation: an initiative of international brands and retailers, manufacturers, and trade unions to address the issue of living wages in the textile and garment supply chain) put pressure on manufacturers to speed up the introduction of new technologies?

Tanning and leather similarly has been resistant to technological changes to some extent, but this is no longer necessarily the case. The effects can be massive; in the tanning and leather industry in India, employment has already shrunk from nearly 200,000 to about 30,000 (albeit due to a combination of factors, not solely technological change).

Indeed, increasingly stringent quality-control tolerances will demand that suppliers of textiles, garments and leather adopt high technology. Parts of the lower-skilled garments sector could be affected by relocation to European countries – much like in the example of Adidas – that allow companies to produce using largely digitalized methods but sell their products at a higher price because of a higher quality and the "Made in Europe" seal that appeals well in the market.

3.2 Medium impact of Industry 4.0 – digitalization in already heavily automated sectors: Particular Impacts in Aerospace, Automotive, Chemicals, Materials, and Pharmaceuticals, Pulp and Paper, Rubber, Shipbuilding and Shipbreaking

Aerospace Sector

With Industry 4.0 being able to provide customized solutions to consumer needs, even sectors like aerospace can experience significant impacts from the application of advanced digitalization in manufacturing. Although automation in aerospace is already fairly high, it will be driven even higher through smart robotics during assembly. Part of this will be driven by the need for increasingly tight quality control tolerances to e.g. make sure parts have the minimum weight compatible with strength and safety. Airbus has in fact come out with a strategy for a 2025 smart factory to produce a new line of concept planes using a number of modern technologies: self-driving vehicle technologies will be used in logistics and material handling, smart tools will help workers in the assembly, laser technology will allow for parts in assembly to be matched up perfectly with minimum time and effort. 3D printing is already being used for some of the components used in the airplane: For example, Arconic, an Airbus supplier, produces a 3D-printed titanium bracket for use in regular Airbus series production.

Aerospace is an industrial sector that is very affected by political decisions. Military contracts, export support, trade deals, offsets, and technology transfer all tend to have a greater effect on the sector – at the present time – than technological change. This makes it difficult to analyze the effect of Industry 4.0 on the already high-tech aerospace industry.

Automotive Sector

The automotive sector shares some characteristics with aerospace, discussed above. It is already heavily automated and can therefore be expected to experience even more digitalization in manufacturing. Similar to the aerospace sector, an increase in smart manufacturing is a possibility for this sector as well; however, since the margin of profit for airplanes is a lot higher than for cars, companies will likely invest in an incremental digitalization of factories rather than completely renewing their plants with smart factory technologies. In the supply chain, assistance systems will likely find more use and logistics may be extensively affected by self-driving technologies as well.

What is less clear is the impact of new vehicles on the manufacturing system. It is certain that some manufacturers will seize the opportunity to make fundamental changes to the organization of work and the degree of usage of robotics, while adapting to market demands e.g. for more electric cars and fewer fossil-fuel powered ones. It is clear that there will be a radical change in the transportation market in the near future, driven now by clear policy indications from several governments that internal combustion engines are no longer desired. Daimler has noted that the profit margin on electric cars is (so far) lower than on traditionally-powered cars.

This will increase pressure on automobile manufacturers to eliminate labour to the extent possible.

Chemicals, Pharmaceuticals, Rubber and Paper Sectors

The chemicals, pharmaceuticals, rubber and paper sectors are already relatively advanced with regard to automation. Process control computers are the norm rather than the exception. Relatively few workers are needed in production when processes are running smoothly. However increased computer-assisted manufacturing and further advanced digitalization can be expected in the future for these high value-added products where the payback period for such investments will be short. These sectors are dominated by large multinational enterprises (MNEs) for which it might be economical to invest into quite sophisticated digitalization technologies.

However, particularly in developing countries, the sector has continued to employ significant numbers of workers – particularly in areas such as packaging and shipping. These could be at risk. Recently, Duc Giang Chemical & Detergent Powder JSC replaced almost 90 percent of its workforce at a detergent factory in Vietnam, with robots. If this is a cost-attractive option in Vietnam – which until now has been a destination for companies seeking a low-cost workforce – then we may be witnessing the beginning of the end of low wages as a competitive advantage.

A particular concern in the chemicals sector, shared with the energy sector, is that there is no longer a sufficient number of human operators on site in many chemical plants to deal with a real emergency, should automatic safeguards and shutdowns not be sufficient. Given that many sites contain very hazardous materials, this has already created an increased level of risk for both workers and the communities that surround chemical plants.

Materials Sector

The materials sector is right now undergoing a major change: while until recently, the same analysis as for base metals would have been valid, new studies show that these companies are much more affected by digitalization than previously thought, e.g. Saint-Gobain is now among the top-ten affected MNC's in France with respect to consequences of digitalization:

- Customers can create their own "recipes" for specialized materials on-line with their own specifications
- Materials companies offer web-based customer-care and customer relations systems as well as joint web-based applications platforms.
- Automated extraction processes (as in the mining industries)
- Fully automatized end-to-end (extraction > processing > (packaging) > transportation) production processes
- Self-analyzing kiln or furnace maintenance technology (and/or augmented reality applications for service technicians)

This process also changes the whole setup in the materials industries and changes the workplaces in these industries. This development is especially challenging since we are talking about business-to-business relations since hardly any consumer “buys” directly from a cement or glass or high-tech ceramics producer.

Shipbuilding and Shipbreaking Sectors

Shipbuilding is a manufacturing process that can be compared in some ways to aerospace and automotive but tends to involve more human labour because of the size and weight of the components. Each ship is more-or-less a custom build, making automation difficult but not impossible. In the short term, information systems that monitor the progress of individual components of a ship from its origins in the supply chain to its installation on the ship will become increasingly sophisticated and important. Specific areas of construction and components will be subject to digitalization and increasing automation. In the longer term, sophisticated heavy robots can be expected to take over a great deal of the manufacturing process.

Shipbreaking on the other hand is very much based on large numbers of manual workers dismantling retired vessels for recycling in a very low-technology manner. That is why this industry mainly takes place today in the low-wage regions of e.g. India, Pakistan and Bangladesh. Furthermore since each ship is different and the work environment is difficult to say the least, digitalization and the involvement of robots can be expected to proceed slowly in this sector so long as wages remain low. In the long term, however, giant machinery could recycle ships effectively. Digitally stored information about the exact assembly of each ship could enable precise identification of which parts can be recycled and how best to disassemble them. The physical breaking up of a ship for recycling can also be done by machines with sufficient power. This technology exists; it is only a question of when the capital costs of such information systems and massive machines will be justifiable in comparison to wage costs.

3.3 High impact of Industry 4.0 – most direct impacts on industrial sectors: Particular Impacts in, Energy, ICT, Electronics and Electrical, Mechanical Engineering, and IndustriALL’s White Collar Workers

Energy Sector

The digitalization of manufacturing changes industries not only with regard to the production, but also with regard to energy production and consumption. The decentralization of the energy production and distribution grid has its effects on the energy industry as well. Presently, the renewable energy sources best position to compete with fossil fuels on a cost basis are wind, and solar (other types of energy source may also be competitive in the near future). These pose their own problems in terms of feeding a grid. A greater share of energy will be generated and consumed locally. When production plants are able to self-supply a large part of their energy, centralized power plants will likely be decreasing in number. At the same time, jobs will be created locally and decentralized at the plant level and especially in renewable energies. Fossil fuel power plants could experience closures and job losses – not only because of the decentralization of the energy grid in the context of Industry 4.0, but also in the aftermath of the SDGs and the Paris Climate Agreement achieved at COP21 (the 21st Conference of the Parties to the United Nations Framework Convention on Climate Change). Electrical utility workers will face a rapidly transforming industry with respect to the distribution grid, as well.

Over the next couple of decades, the oil and gas industry will experience digital disruption rates that will drastically change the common operating procedures we know today. Using Industry 4.0 technologies, oil and gas companies will carry out fully automated drilling operations, standalone pipeline inspection, and rigging and abandonment of rigged wells. We can imagine that the digital disruption of oil and gas will occur broadly and rapidly. Oil prices will strongly affect the rate of digital transformation of the industry.

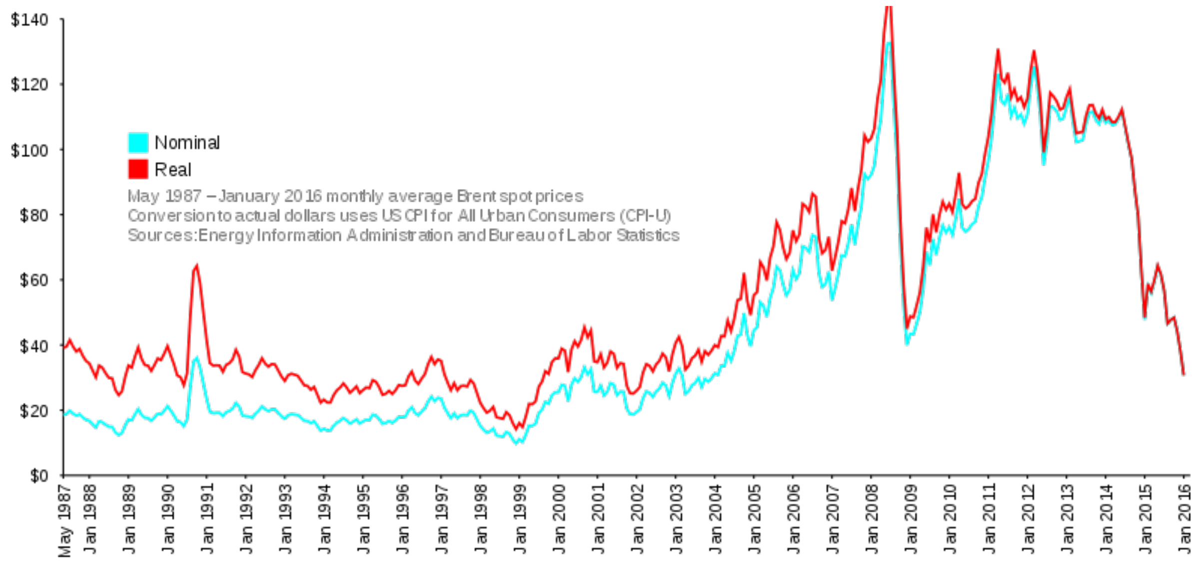


Figure 8: Brent Spot Oil Prices. Source: Wikimedia commons, file: Brent_Spot_monthly.svg#file

Oil prices have recently been volatile, with a significant crash of oil price in 2008 and following a price recovery from that crisis, steep decreases again in 2014-16 (Figure 8). During the more recent oil price crisis, oil companies scaled back their investments in oil and instead started to invest in technology. According to information compiled by industry experts, well engineering is responsible for approximately 40 percent of the development costs of a typical offshore deep-water project. In order to reduce total investment in this area, several initiatives have been undertaken in the search for a more cost-effective way to build subsea wells. Innovative technologies, such as intelligent termination systems, allow multiple production areas to be utilized by the same well, reducing the need to invest in the exploration and production of an area consisting of several sites or sites of production.

Along with the chemical industry, the continuous downsizing of the workforce at oil refineries and pipeline companies (for example) has raised questions of safety. Increasingly reliant on automatic shutdown devices to manage emergencies, there simply are too few workers to respond if these should fail to function as designed.

ICT, Electrical and Electronics Sector

The ICT, Electrical, and Electronics (ICT) sector may experience significant growth as it is the supplier of many of the technologies that will be sought by other industrial sectors. Digitalization of industrial manufacturing implies that machinery as well as controlling systems require sophisticated information and communications technologies and an increased demand in the ICT, electrical and electronics sector. There is clear value of looking at industry in general in terms of integrated value chains rather than isolated factories. Viewed in this light, it is obvious that governments must regulate to prevent two or three leading technology companies from reaping most of the benefits of industrial transformation, leaving only crumbs for others in the value chain.

Research on this seems to agree that jobs will be gained in this sector in the context of Industry 4.0. Surprisingly, this sector overall has not made strong efforts to digitalize commercial grade ICT production – at least at the point of product assembly, although manufacture of chips and electronic components are already highly digitalized. Given the strong regional clustering in Asia it would lead to the belief that this sector would be relatively unaffected by automation in the short term. This is due to the current low wages in the labour-intensive manufacturing countries of the region making a high-level technological transformation being uneconomical in this context. However, Foxconn, as described earlier, is an example of how initial efforts in ICT are already being made in private use ICT products (like smartphones, tablets etc.) and hence it is not unlikely that similar transformations could be done in commercial grade ICT. Overall, this sector is most likely to be affected at least by assistance systems and probably further advanced robotics and workforce downsizing in the future. These assembly processes can be heavily automated. It is also worth mentioning that there will likely be a regional division of labour between the actual industrial design (jobs won, likely in the developed world) and industrial manufacturing (jobs lost, likely in the developing world).

In addition, as the industry sector that will lead others to a digitalized world, it is particularly in this sector that IndustriALL must strongly make the point that ICT leaders have a moral obligation to address social, and not just business, needs. The conversation must start here about the impact on employment, skills, and data ownership and privacy, among other things.

Mechanical Engineering Sector

Aside from the ICT sector, mechanical engineering will be one of the most affected sectors by the digitalization of manufacturing. New production needs new machinery and so there will be an increased demand for high-tech mechanical engineering. The transformation of this sector has in fact many similarities with the systematics in ICT, because likely industrial design and industrial manufacturing will experience very different employment effects. When the production of mechanical engineering equipment can be digitalized, and other disruptive modern manufacturing techniques like 3D printing can be used to replace human labour, their production will experience job losses while in industrial design and various engineering disciplines, through the rising demand for advanced mechanical engineering equipment, jobs may be won. However, as mentioned in chapter 3, the job profiles between those lost and those won are in fact very different. A white-collarization of not only (but including) services but also in production, creation and maintenance itself is already visible: from technician to engineer, from engineer to full-service customer-care-person.

White Collar Workers Sector

IndustriALL's "white-collar worker" sector is composed of workers whose work is involved primarily in obtaining, handling, using, manipulating, analyzing and distributing information and knowledge as opposed to goods or products – even if they touch the good or product at times. Until recently, such workers were thought to be relatively immune to the effects of automation and outsourcing. This is no longer the case, and artificial intelligence systems may be expected to have a significant impact on white collar jobs. Administrative, technical support, analysis and engineering jobs are all susceptible to replacement by advanced computers and ultimately artificial intelligence systems.

One consequence of the digital revolution will be the transformation of many formerly blue-collar jobs to more closely resemble what we have in the past characterized as white-collar jobs. Production will be more and more about controlling the process, rather than doing it. Maintenance jobs may be transferred to service providers. This will have an impact on trade union's traditional views of themselves and on IndustriALL's traditional sectoral divisions.

Unfortunately, white collar work in a world of industry 4.0 will become increasingly stressful. Already it can be observed that white-collar hours of work tend to increase, the line between work and free time becomes more and more blurry, mobile work causes additional stress and health issues and the automation of routine white collar tasks increases pressure on white collar workers in other areas. Add to this a more rapid change of skills and a constant pressure to readjust and the white collar workplace becomes perfect recipe for a drastic increase in cases of burn-out and depression, with accompanying stress-related diseases such as circulatory diseases and cancer.

4. Current and Future Impacts of Industry 4.0 on Union Actions and Activities

Fundamental changes to the economy are coming, driven by a variety of forces (figure 9). With digitalization of products, big data, and the ability to understand and react to individual customer needs quickly and accurately we are at an inflection point: the rules from the industrial era of mass production are giving way to a digital era of individualization and optimization. Could we be witnessing the end of economies of scale – which led to the large factories and large concentrations of workers that have been the backbone of unions' industrial might? How does Industry 4.0 contribute to the changing world of work, which will also be under pressure from globalization, inequalities, climate change, and changing demographics?

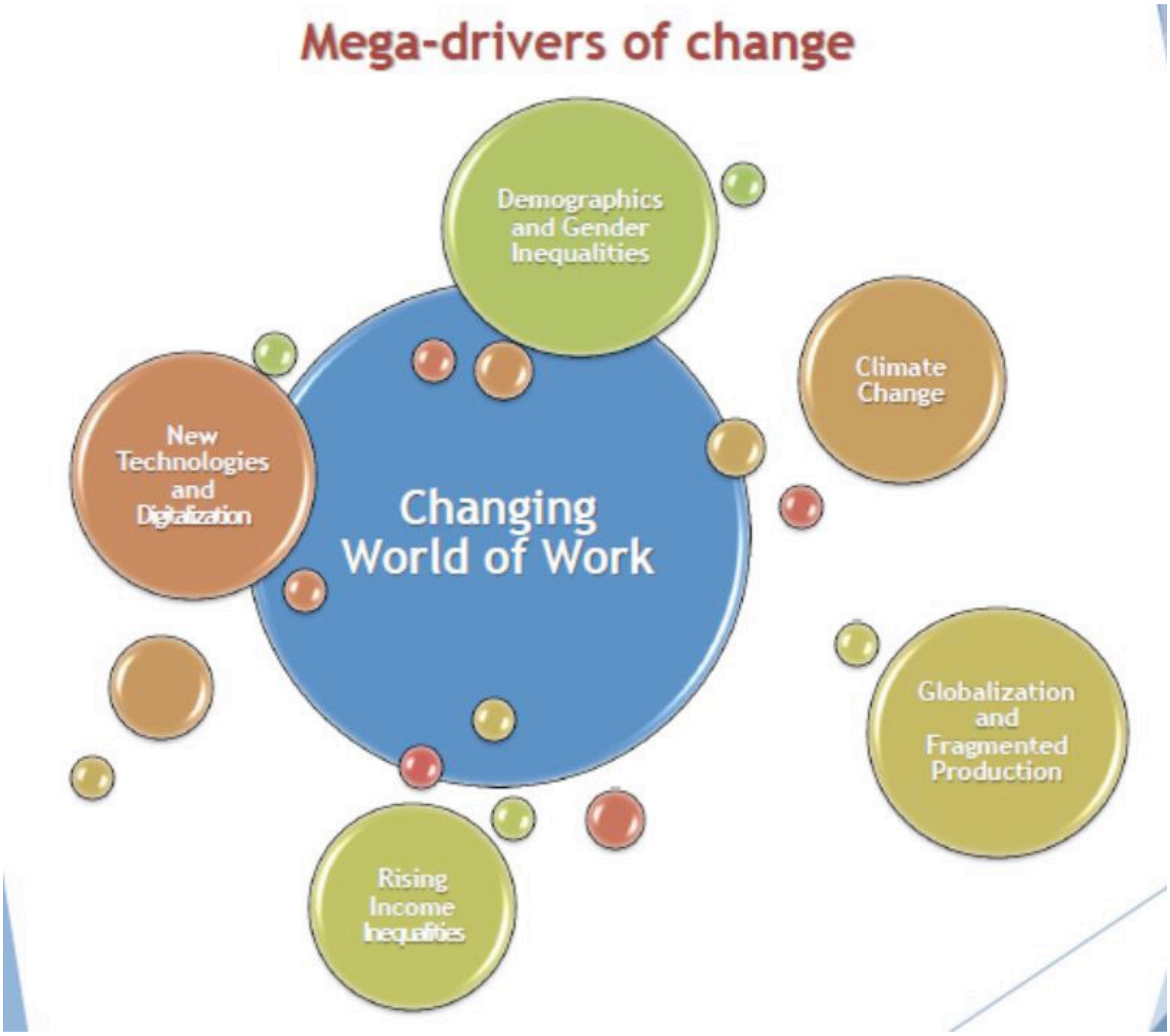


Figure 9: forces of change

For trade unions to remain strong and relevant, some new thinking and structures are needed - "Trade Union 4.0" needs to be invented and implemented, as an effective response to Industry 4.0. To ensure workers' rights, trade unions will need to adapt their structures and culture to new realities: appealing to a younger and more diverse and geographically dispersed workforce, devising ways to organize isolated workers who may be on individual contracts in the so-called "gig economy". The fundamental need for trade unions to defend workers' rights, will remain.

4.1. Changing Membership Profile, Recruitment and Union Structures

To respond to the impacts of Industry 4.0 the exact shape that this will take has yet to be determined. Besides protecting the interests of today's workers, "trade union 4.0" will have to respond to the needs and aspirations of a younger, more diverse, and perhaps more flexible workforce than has traditionally been the case. Trade unions also need to deal with the "white-collarization" of the workforce; particularly amongst younger workers. This will be a challenge to global unions, as losing relevance with this group could be the end of the labour movement.

However there are also opportunities here, as the increased pressure on white-collar workers means they will need unions to address working conditions.

Workers in non-traditional forms of employment in e.g. crowd-workers, platform-workers or gig workers in pseudo-autonomy, need representation as well. Trade unions have sometimes been quicker to condemn these forms of work without necessarily considering the needs of those workers already in them. IG Metall, for example, has recently initiated a programme of outreach to these precarious workers. Legislative and regulatory barriers to doing so exist in some jurisdictions, and these must be challenged.

It is also clear that the labour movement needs more members – but fewer unions: in too many regions of the world, we waste a great deal of our energy competing amongst ourselves. Trade union mergers and consolidations must be part of the discussion of how to adapt to the rapidly changing world of work.

4.2. Collective Bargaining and Social Dialogue

Since collective bargaining is our most effective tool, we must consider addressing Industry 4.0 matters in collective bargaining agreements.

Successful collective bargaining is a function of union power, as an effective counterbalance to the power of capital. Building union power means building union density within organizations capable of using that collective workers' power. Globally, less than 10 percent of the workforce is organized.

Social dialogue is most effective in those jurisdictions that grant legislative and regulatory backing to it. This, too, is most easily achieved when unions have sufficient collective power to have an impact on political structures.

The transformations brought by Industry 4.0 will challenge trade unions' collective strength to advance the interests of today's and tomorrow's workers, as well as the families, communities, and broader society that depend on them.

4.3. Industrial Relations:

Industrial relations has traditionally meant the relationship between employers and trade unions, within the legislative and regulatory framework governing that relationship in a particular jurisdiction. Winning a fair share of profits and productivity gains, in terms of improved wages, content of work and working conditions, and benefits will be essential. If Industry 4.0 effectively reduces the number of workers needed, then trade unions will have to look hard at new benchmarks such as reduced work weeks (fewer days per week) or even a 4-hour day or a combination of these. Diverting some of the productivity gains to social welfare programs, such as pensions, by means of a tax on levels of automation, has been proposed by the Australian Workers' Union. This automation tax would price the loss of jobs and resulting re-education and welfare expenses. Revenue could be used to support social programmes and fund a Just Transition. At the very least it would force a consideration of the impact of new technologies on the workplace, and on society.

In today's context, with industrial relations under attack even in societies that have until now respected it, the additional stresses caused by Industry 4.0 will demand aggressive organizing by the labour movement to keep up.

5. Worker and Trade Union Rights

Industry 4.0 is undoubtedly a huge transformation that will hit sectors and regions differently, but that will affect each one in one way or another. There is no victory possible in defending the indefensible and in trying to keep this transitions from coming – from an economic point of view there are simply too many benefits for both companies and governments.

That is not to suggest that Industry 4.0 will not be used by anti-union employers and governments to attack workers' rights: it will. Throughout the several previous industrial revolutions trade unions have been most successful not in preventing transformations but in making a possibly socially disastrous transformation a lot more livable and ensuring that workers, their families and community interests remain protected and articulated toward governments and companies.

Today, trade unions are more important than ever as we face a new and drastic industrial transformation - they are crucial players to manage the socio-economic and political change. Otherwise, the benefits of Industry 4.0 will flow entirely to employers and owners of capital; not to workers, and political instability will be the result – a result already in play in some regions as their pathway to full development becomes restricted or blocked.

Although workplaces may be fundamentally transformed, it is crucial that the basic rights of workers and trade unions are respected. These include particularly those mentioned in the International Labour Organization "Declaration on Fundamental Principles and Rights at Work (sometimes called ILO Core Conventions), which cover collective negotiation, forced labour, child labour and discrimination. The conventions concerned are as follows:

- Freedom of Association and Protection of the Right to Organise Convention, 1948 (No. 87)
- Right to Organise and Collective Bargaining Convention, 1951 (No. 98)
- Forced Labour Convention, 1930 (No. 29)
- Abolition of Forced Labour Convention, 1957 (No. 105)
- Minimum Age Convention, 1973 (No. 138)
- Worst Forms of Child Labour Convention, 1999 (No. 182)
- Equal Remuneration Convention, 1951 (No. 100)

• Discrimination (Employment and Occupation) Convention, 1958 (No. 111)

In addition, instruments of international law such as the United Nations' Guiding Principles on Business and Human Rights (2011), the OECD Guidelines for Multinational Enterprises (2011) as well as the ILO Tripartite declaration of principles concerning multinational enterprises and social policy - 4th edition (2014) will be more important than ever.

As the digitalisation of the workplace progresses, several points must be won:

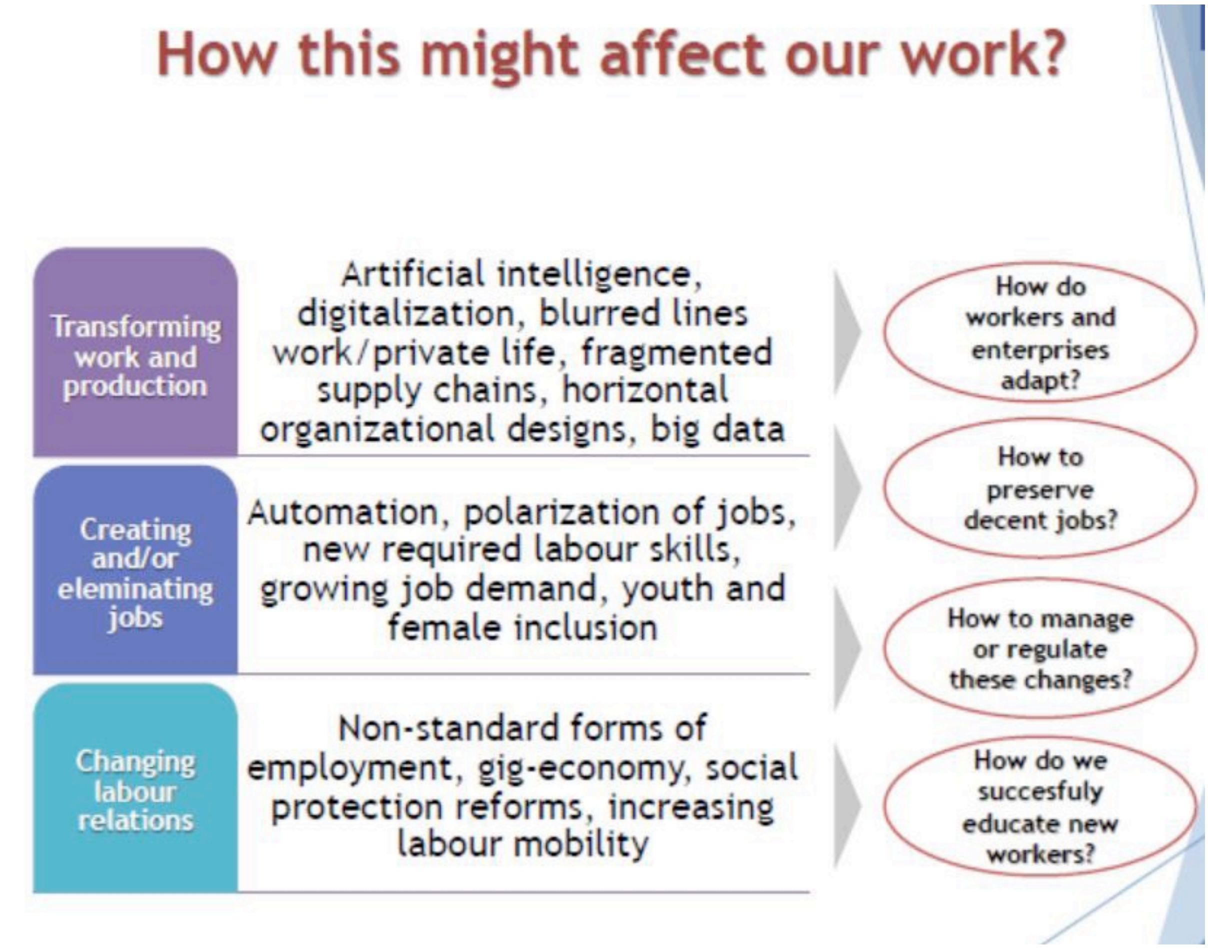
• the right to information and consultation rights by workers representatives, at the local, regional, national and international levels;

• the right to education and training;

• the right to defined levels of privacy, at work and at home.

To ensure workers' rights, trade unions will need to adapt their structures and culture to the new realities of the Industry 4.0 workplace, e.g. by devising ways to organize isolated workers who may be on individual contracts in the so-called "gig economy".

Figure 10: "How Industry 4.0 might affect our work?"



6. A Just Transition

Industry 4.0 may lead into greater inequalities inside societies as well as risk opening up the regional divide between the developed and the developing world to completely new proportions. Precarious work situations, pressure on wages and possible workforce downsizing are some of the most drastic negative impacts this revolution may have on our societies. At the same time, Industry 4.0 also comes with a number of positive effects: Digitalization of manufacturing could mean an improvement in workers' health and safety at the workplace when the most hazardous jobs could – and should – be done by robots (for example, the mining of highly radioactive metals). Other tasks could be made more ergonomic. Some tasks in controlling don't require being physically present at the plant and could mean that workers with families, and in particular but not only women, could balance family and career better (improved work-life balance). The use of assistance systems and the inherent demand for medium skilled labour could be a powerful boost for emerging markets with a medium average of education and skill in population. The decentralization of the energy production and distribution grid gives new opportunities to regions of the world and a more reliable source of energy to both production plants, as well as to surrounding communities. However, the potential and expectation of workplace improvements will only become reality if trade unions are able to deliver it through political action, collective bargaining, and industrial action.

And yet, the benefits and risks are clustered very differently in the regions: Industrial design will become an extremely important pillar of the economy in the future when new and modern technologies are being developed and will likely experience job gains, while industrial manufacturing will likely experience these effects quite differently through automation and job losses. Workers cannot be the ones paying for a transformation that they did not decide upon or even have a voice in. Even with the more economical and environmentally sustainable production that Industry 4.0 promises, workers still need to support their families, invest in their children's futures, and make a comfortable living. Today, where the use of digitalization in industry is still relatively small, many workers already cannot do that because of the recklessness and unwillingness of some companies to pay a living wage, change precarious working conditions and improve workers' occupational health and safety. We cannot allow that in the context of this new and approaching transformation.

The weakest links in our global economy cannot be asked to pay the price while others thrive and companies make billions in revenues. A Just Transition, originally proposed in response to the need to protect the natural environment, is now more important than ever when it comes to Industry 4.0. The aim is not to halt Industry 4.0 – that aim would fail – but it is to make this transformation socially sustainable and just, to all workers alike. IndustriALL wants a future of work that embraces the positive impacts that Industry 4.0 may bring for all of society while making sure that workers aren't left to pay the debts of companies and governments unwilling to make this transition socially responsible. We cannot allow the benefits to be privatized and the costs to be socialized.

It is up to us to define what would be needed for the transition to be perceived by workers as a Just Transition, and then fight to achieve that standard. Strong social safety nets are a prerequisite for a Just Transition program, but a resort to such safety nets will never be labour's first choice. Our first choice, and the most Just Transition possible, will always be to create, evolve, or maintain sustainable jobs.

A Just Transition program is meant to be an all-encompassing, flexible approach to helping workers, their families, and their communities. Just Transition is not a suicide pact. It is not merely an enhanced unemployment program. It must involve workers in its design, and it must be customized to each situation in order to avoid it being viewed as simply an enhanced unemployment program. A Just Transition program might even, plausibly, assist in the creative restructuring of obsolete industrial sites. And it must keep workers and their unions whole.

Traditional labour market adjustment programs have often been top-down programs with the needs and goals defined by business, although there are examples of more inclusive processes in Europe. A Just Transition, on the other hand, would offer those most affected the greatest choice in what happens to them. Labour market adjustment programs should take account of individual, family, and community needs and wants. Some workers might want enhanced early retirement. Others might want to go to a college or university and study a field unrelated to what they were doing. Some might want to enter an apprenticeship program. If some new jobs are being created in the transition to a digitalized economy, those displaced from disfavoured jobs should have the right of first refusal, with moving and other assistance if necessary. It is important for workers that their rights as union members be protected, as well, and it is entirely reasonable for unions to demand institutional stability – protection for the union as an institution – through the transition period, as well. This could mean, for example, voluntary recognition of the union where new jobs are being created through the process of digitalization.

The question is fundamentally who pays for, and who benefits from, a transition to digitalization. Workers and their trade unions need to be part of the decision making process when the fates of millions of workers are being decided upon. This also means, however, that international workers' solidarity is more important than ever.

7. Conclusions

Technological change can lead to good or bad outcomes depending upon humans and human decisions. Where Industry 4.0 is adopted, labour must insist that there are benefits for workers.

Where digitalization and advanced technologies are presented as advantageous by employers or governments, we must ask what the benefit will be to workers, and to society at large, of their introduction. IG Metall's Jochen Schroth offers the following table (figure 11) for analysis of the benefit, which can be very useful (translated from Digitalization and Industry 4.0 - Strategies for implementing company policy, IG Metall 2017).

The two columns, left and right, imply advantage to humans versus advantage to machines. Unless the changes adhere to the principles outlined in the left hand column, we must reject them. *Figure 11:*

	Humans use system	***System uses humans***
Control of work	Upgrading job qualifications, high employee influence over objectives and design of work and tasks	Downgrading of jobs; narrow definition of tasks with a high level of standardization
Organi-zation of work	Cooperation, participation and complex interactions between groups of employees	High responsibility/ low scope for action
Technology	Highly demanding and unattractive tasks performed e.g. by lightweight robots	Goal of full automation; number of employees as few as possible
Qualifi-cations / Compe-tences	Comprehensive education and training (on and off the job), better opportunities for upward mobility	Only training on the job
Data	Access to information and knowledge for problem solving; personal data is protected	Use of personal data to control behavior and increase output

Forms of human-centred technology must be promoted by unions, employers and governments, with better outcomes for workers, more responsive technologies which don't just leave the response to technologies to consumers, and healthier and safer outcomes. We must make technology work for us and not simply allow Industry 4.0 to define a new wave of intensified work and more precarious work. We must promote collective responses to technology, and limit the power of capital and its desire to promote inequality. When we demand that governments in developed nations also take into account the possible consequences this has on developing nations' economies, it remains clear that national trade union strategies should also account for other national interests in our globalized economy.

Amy Webb, the CEO of a strategy firm in the US, was cited about her reaction to Industry 4.0 saying "The collar of the future is a hoodie." And while that might be true, we need to make sure that the hoodies in the world and the blue and white collars in the world remain unified in the process of interest articulation. Undoubtedly, this also means that trade unions may stumble across a number of problems in keeping members when the numbers of traditional industrial workers are falling. Trade unions need to be prepared for both: Facing new strategies with regard to memberships so their numbers (and hence their impact) are not falling and demanding a seat at the table with governments and companies when decisions about Industry 4.0 are made. Sometimes, we must demand that the table be constructed since many governments are not yet addressing Industry 4.0 in any systematic manner!

For trade unions to remain strong and relevant, some new thinking and structures are needed - "Trade Union 4.0" needs to be invented and implemented to respond to the impacts of Industry 4.0. The exact shape that this will take has yet to be determined but, besides protecting the interests of today's workers, it will have to respond to the needs and aspirations of a younger, more diverse, and perhaps more flexible workforce than has traditionally been the case. Losing relevance with this group would be the end of the labour movement. It is also clear that the labour movement needs more members – but fewer unions. Building union power means building union density within organizations capable of using collective workers' power.

Industry 4.0 will require a rethinking of the current reliance on wealth distribution through dependent gainful employment and in the context of Just Transition, a reform of our definition of productiveness is absolutely crucial. Human needs must be prioritized. The value that is given to human work will change, but the definition of productive industrial work might not be fit for the new transformation that Industry 4.0 means for our societies; and our ideas about the preferred mechanism of wealth distribution will need to adapt or evolve. Schemes such as a guaranteed minimum income not contingent on employment, need closer examination especially on taxation. So too does the participation of employers in the financing of education and training so that life-long learning can become reality. Furthermore while undoubtedly engineering and technology will be crucial in the future, not everyone can or wants to become and engineer or technician but might instead want to be changing into a job that is traditionally not seen as productive (in the industrial or financial sense), but may have significant positive, innovative effects on society (like e.g. music, or literature). This transformation hence allows for rethinking of a variety of traditional policy fields and a new discussion about what productivity means in this context will be necessary (i.e. care work, artists, etc.) – because in the long run, no human worker will be able to compete with the productivity of machines, robots and AI – factories as we know them today will be radically transformed or disappear altogether.

It is clear that Industry 4.0 is a global phenomenon requiring global action and powerful unions and union activities to accompany this transition in order to maximize the positive, and mitigate some of the negative effects; and ensure that workers' interests are taken into account. For IndustriALL, political action is needed now and is required to:

- acknowledge that Industry 4.0 is not just another technological innovation, but instead quite possibly the industrial transformation with the strongest impact on the workforce in the history of manufacturing
- globally discuss the potential threats and opportunities with its members and make Industry 4.0 a top priority for strategic policy in the future

- formulate a policy on Industry 4.0 aligned with the existing Sustainable Industrial Policy Action Plan
- take a seat at the table (or demand the creation of one!) with governments and companies when the fates of millions of workers, their families and communities are decided upon
- formulate a consistent and extensive Just Transition proposal to be part of the discussion with governments and companies
- make consequences and changes along with Industry 4.0 part of the agenda in Social Dialogue committees and Global Framework Agreement negotiations
- engage intensively and join forces with the ILO[1] as well as with the UN on behalf of the Sustainable Development Goals given the commitment to decent work, reduced inequalities and partnership to ensure a Just Transition that does not worsen the pre-existing inequalities between capital and labor, especially in the developing world
- encourage IndustriALL member unions lobby to upgrade national educational policies to match the changing skills demand following Industry 4.0, but also to teach flexibility and innovation in all of the dimensions of sustainability
- consider the possibilities of taking an active role in the design and delivery of education and training for the digital age
- engage in intense union building activities, especially in the developing world and sectors with predominantly precarious work, and with a focus on women and young workers, minorities, and equity-seeking groups
- develop a strategy for trade union roles in the future given the decreasing number of traditional laborers and a possible loss in membership

In the emerging borderless, connected, and globalized economy new strategies will be key to maintaining and increasing the importance of the global trade union movement, if not a condition of its survival.

Sustainable industrial policy means having a plan. The contents of that plan must be based on an assessment of how to steer towards a destination we want as a society, rather than a destination that is favourable to only a few. The drive towards the Fourth Industrial Revolution makes a discussion of what a sustainable industrial policy would look like, much more urgent. This can only happen with the full participation of all major stakeholders – particularly labour.

1. *See e.g. The Future of Work Initiative/Global Commission on the Future of Work (http://www.regeringen.se/4a42ad/contentassets/6062511d88d34aa39a897b0c02720556/informationsmaterial-om-fn-kommissionens-arbete.pdf)*

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