Working on the robot society

Visions and insights from science concerning the relationship between technology and employment

Rinie van Est & Linda Kool (eds.)

Rathenau Instituut

The Rathenau Instituut promotes the formation of political and public opinion on science and technology. To this end, the institute studies the organization and development of science systems, publishes texts on the social impact of new technologies, and organizes debates on issues and dilemmas in science and technology.

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Rathenau Instituut
Anna van Saksenlaan 51

Postal address:
Postbus 95366
2509 CJ The Hague
The Netherlands

Tel: +31 (0)70-342 15 42
E-mail: info@rathenau.nl
Website: www.rathenau.nl

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Editors
Rinie van Est and Linda Kool

Authors
Rinie van Est, Ira van Keulen, Linda Kool, Arnoud van Waes, and Frans Brom
(Rathenau Instituut)
Frans van der Zee and Govert Gijsbers (TNO)
Jan Korsten, Harry Lintsen and Johan Schot (Foundation for the History of Technology)

Foreword

Brigitte van der Burg

Different ideas circulate within society about the impact of technological developments and globalization on our lives, jobs, and prosperity. There is uncertainty about the effects of breakthroughs such as nanotechnology, artificial intelligence, robotization, and 3D printing. Will these developments herald the destruction of jobs or, conversely, the creation of different, and perhaps even more jobs? Are we creating winners and losers on the labour market? If so, who will these winners and losers be? Or will we, after a period of adaptation, perhaps all be better off?

What can we learn from great periods of technological change in the past, such as the industrial revolution? And what is the role of politics? What should the political community do, and what should it allow? How can politics and society enable us to seize these opportunities and at the same time deal with the risks prudently?

The House of Representatives of the Dutch Parliament, specifically the Standing Committee for Social Affairs and Employment, has felt it was necessary to gain a clearer understanding of the consequences of technological developments for the labour market. It wanted to address this important issue proactively. The House of Representatives accordingly asked the Rathenau Instituut to draw up a report to clarify current scientific knowledge concerning the impact of technological developments on the labour market, and on prosperity over time. A study of this kind is important to gain scientific insights and use the lessons of history to underpin political debate. This could dispel certain 'myths' and fill in gaps in our knowledge. As in many other areas, the close links between science and politics have again proven to be of huge value here.

The present report by the Rathenau Instituut provides the insights requested. It thus constitutes a shared fund of knowledge on the basis of which everyone can, from his or her conception of society and political perspective, weigh up the opportunities and risks that technological developments may present for employment and economic growth, both now and in the future. Looking back, the report also shows us that such technological developments have often given us different jobs, more jobs, and greater prosperity as well. An important question continues to be whether, with current technological developments, things will turn out the same way.

Change is inevitable and will affect every one of us, whether we want it or not. How we cope with change will determine future levels of employment and prosperity in our country. A pronouncement made by Franklin D. Roosevelt in the last century can guide us here: "The only limit to our realization of tomorrow will be our doubts of today. Let us move forward with strong and active faith."

Brigitte van der Burg
Chair of the House of Representatives' Committee for Social Affairs and Employment

Foreword

Melanie Peters

Before catching the train home, I sometimes pop into the *AH To Go* market at Den Haag Centraal railway station in the Dutch city of The Hague. I'm faced with long queues in front of the staffed checkouts, but there is nobody at the self-service checkouts. What makes people queue up when they have a train to catch?

More and more frequently, we are coming into contact with robots or ongoing automation in our personal and professional lives. For a long time, developments in robotics and artificial intelligence seemed a long way off. We laughed about the amateurish level of the applications. But developments now seem to have gone much faster than we expected. The speech recognition in my mobile phone works well, a robotic lawnmower is now affordable, nobody is fazed when a story about drones comes on the news, and soon a self-driving bus will be operating in the Dutch municipality of Wageningen. Robotization is affecting more areas of society than initially expected, including healthcare, transport, police, the armed forces, and the world of work, to name but a few.

The Rathenau Instituut has considerable experience of research on robotization and computerization. These are issues which our Work Programme for 2015-2016 also addresses. In this study, we have – at the request of the House of Representatives' Committee for Social Affairs and Employment – set out current scientific findings concerning the impact of information technology on employment in the past, present, and future. Strikingly, there is reasonable consensus among scientists about the relationship between information technology and work in the recent past. But there is very little consensus as regards predictions for the future.

According to a recent survey conducted by the Dutch employment agency Intermediair, the average Dutch person describes the impact of artificial intelligence on the labour market as 'alarming'. This is understandable because computers can now take over routine cognitive work, and this is leading to 'job polarization'. Demand for medium-skilled work has declined, whereas demand for chiefly high-skilled and low-skilled work is growing.

New technologies have always sparked concerns within society. In 1979 (in other words, before the advent of the personal computer), the Dutch Government appointed a committee to investigate the social consequences of microelectronics. That committee's report formed the basis for a targeted industrial policy and placed the 'information society' on the social and political agenda. Heading the committee was Gerhart Rathenau, a former director of a member of WRR (Netherlands Scientific Council for Government Policy), the same man after whom our institute is named.

Gerhart Rathenau spoke of an information society. Following in his footsteps, we now propose using the term ‘robot society’ in this report to move forward the debate about digitization and the impact on work. In this report, we want to provide a fund of knowledge for the political and societal debate to come. It is important that we in the Netherlands, as a country, now start thinking about how we can and want to shape society so that this development is an attractive prospect for everyone.

Dr. Ir. Melanie Peters
Director of the Rathenau Instituut

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Summary

The international debate about robotization and the potential impact on employment has become fiercer in recent years. On the one hand, there are concerns about technological unemployment and job polarization (erosion of employment in middle class jobs which require midlevel skills). Others see chiefly opportunities and argue that in the past, innovation has always sparked more economic growth, prosperity, and welfare; and smart machines will do so again. The Standing Committee for Social Affairs and Employment (SAE) of the House of Representatives of the Dutch Parliament has asked the Rathenau Instituut to conduct research on the latest scientific findings concerning the impact of technological developments on employment and thereby provide a shared fund of knowledge for the coming societal and political debate.

The Standing Committee for SAE has formulated the following central question: what current scientific knowledge is available on the impact of technological developments on employment? The associated secondary questions concern the availability of relevant and current scientific knowledge regarding the following aspects:

1. The impact of technological developments (mechanization, automation, etc.) on employment in the past.
2. The potential impact of technological developments on future employment.
3. Scope for responding, through policy, to future effects on employment, for example by means of training.

The relationship between technological development and employment is very complex. Scientific research on these questions is being carried out in very different fields, from the perspective of various scientific disciplines and levels of aggregation. This report outlines the main findings from science, with the aim of allowing a sound and well informed political debate.

The study comprises a review of the literature, media analysis of the policy options, and interviews with scientific experts. The aim of the interviews is to verify whether relevant literature has been included in the review, and to evaluate the literature found in terms of its scientific value and to explore policy options. Further reflection on and analysis of these policy options are needed to come up with specific policy recommendations.

The past: long-term

Second machine age and the robot internet
Historians of technology often mention three industrial revolutions: the introduction of steam, electricity, and information technology (IT). The distinction

between the first and second machine age is also important in the debate about technology and work. The first machine age covers the first and second industrial revolution. That age involved machines that provide muscle power. The third industrial revolution – the IT revolution – is the second machine age, in which machines also supply thinking power. In thinking about the relationship between technology and employment, we should therefore consider the technical characteristics of the current IT revolution. This entails not only physical robots but also technologies such as 'softbots,' artificial intelligence, sensor networks, and data analytics. It involves the advent of the 'Internet of Robotic Things', or the robot internet. In this way the internet is being expanded with senses (sensors) and hands and feet (actuators), and, as a result of machine learning and artificial intelligence, the internet is also becoming 'smart'. The management and analysis of large volumes of data is of key importance in this regard. Machines from the first and second machine age provide scope for taking over both physical and cognitive work from humans. Whether or not such scope can be utilized depends, however, on how production and work are organized.

From mechanical to digital Taylorism

The continuous search for new forms of organization is usually driven by rationalization, or the quest for greater efficiency and control, including control over the worker. In the first machine age, starting in 1910 the traditional factory was redesigned into 'a big efficient machine' on the basis of (mechanical) Taylorism. This was done by splitting work processes into simple tasks, thus allowing certain physical tasks to be mechanized and later automated.

In the second machine age, and through the advent of IT, the services sector since the early 1980s came under the influence of (digital) Taylorism . Where mechanical Taylorism allows the automation of physical work, digital Taylorism allows the automation of cognitive work. As a result, it has become possible to outsource, offshore, or automate not only physical but also cognitive tasks. Thinking about new and more efficient ways of organizing things has received fresh impetus since 1995, owing to the arrival of the internet. The internet boosts the internationalization, flexibilization, and 'platformization' of work. We can see the advent of the virtual network organization which seeks to optimize on-demand access to paid and unpaid work. This body of ideas underpins, for example, the way in which Uber uses drivers.

Lessons from the Netherlands' past

In the past, the Netherlands has been able to benefit from the three industrial revolutions described. However, that required foresight and an active adaptation process that often did not take place without setbacks. The government has always played an important part in the introduction of new technologies by creating the right conditions. Firstly, this entails fostering innovation by investing in physical and knowledge infrastructure (such as knowledge institutes and training). The construction of a good transport system (canals, railways, and paved roads) in the first half of the nineteenth century paved the way for the use of coal and steam engines, and thus the growth of, for example, the textile industry in Twente (in the eastern part of The Netherlands) in the second half of the nineteenth century. Extending the electricity grid to the entire Netherlands meant that, in particular, small and medium-sized enterprises could benefit from the potential of the second industrial revolution. Secondly, the government played a key role in regulating new practices, preventing excesses, and sharing prosperity. Examples include social legislation, such as Van Houten's Child Labour Act of 1874, the first Compulsory Education Act of 1901, and the Social Assistance Act enacted in the 1960s.

The past: recent

Two opposing visions

The debate about the relationship between technology and employment is characterized by two opposing visions. According to one vision, innovation leads to economic growth, jobs growth, and an acceptable distribution of prosperity. In this way, technological innovation leads to greater labour productivity and cheaper products, which in turn bring about higher consumption, and thus market growth and more jobs and prosperity. According to the alternate vision, increasing labour productivity through innovation (via labour-saving technology) conversely leads to less employment, and thereby to lower purchasing power and consumption, and thus to shrinking profits and markets, and declining prosperity. The assumptions behind the two visions raise the following secondary questions: within science, what is known about the relationship between the IT revolution and productivity, between IT and the loss and creation of jobs, and about how IT influences our prosperity?

Impact of IT on productivity

The relationship between economic growth and productivity growth, on the one hand, and the role of IT, on the other, is complex. With science focusing increasingly on measuring the contribution of IT to productivity and productivity growth, it has become clear that over the past twenty years, IT has made an important contribution to productivity growth. With regard to automation and robotization and their impact on jobs and economic growth, there has traditionally been a consensus among economists that technological growth in the very short term comes at the expense of jobs, but that this provides new jobs relatively swiftly, within one or two years.

This occurs via 'second-order effects' in which savings achieved by productivity growth flow back into the economy. This consensus has started crumbling since 2010, among not only criticasters such as Brynjolfsson & McAfee but also well-known economists such as Krugman and Summers. This crumbling consensus is based not only on facts – scientific observations concerning employment creation in the short, medium and longer term – but also on changing perspectives on the underlying economic dynamics (see for example various 'diagnoses' of current economic problems by Gordon, Brynjolfsson & McAfee, Cowan, Krugman, Summers, and Rifkin).

IT and the loss/creation of jobs

Since the 1980s, automation has led to job polarization: demand for medium-skilled work has declined, whereas demand for chiefly highly skilled and low-skilled work is rising. In previous technological revolutions, mainly low-skilled, physical work was affected by mechanization and automation. Now, IT is taking over cognitive routine work such as administrative work, the performance of calculations, bookkeeping, the monitoring of processes, or the assessment of products. This is also a consequence of digital Taylorism: the rethinking of work processes and being able to split work into subtasks that can be outsourced, offshored, or automated. Globalization – which also is enabled by IT – therefore also plays a part in the polarization of jobs. Offshoring can be seen as a first step in the codification and automation of tasks. If you can codify work (capture it in rules, such as a telemarketer's script in a call centre), you can readily relocate and automate it. It is now becoming clear that both highly skilled and low-skilled work is no longer 'immune' from automation: all levels of education and training may be affected by automation.

IT and prosperity

IT has differing effects on different occupations and types of job: it is mainly favourable for highly skilled people, and relatively neutral for low-skilled people who perform location-bound work, and exerts pressure principally on middle-class jobs in both industry and the service sector. Where IT allows offshoring, wages come under pressure as a result of growing competition with low-wage countries. Globally, we can see the emergence of a new form of technology-driven accumulation which, prompted by debate about the Uber taxi service, has now come to be known as 'platform capitalism'. Flexibilization and platformization of work are also prompting a debate about the impact of IT on the quality of work and job security. The differences between permanent jobs with high salaries and temporary jobs with lower wages are persistent. In the Netherlands, most people work in paid employment, but the number of workers on flexible contracts and self-employed people is growing. Self-employed people are much more diverse than flexible workers in paid employment. Highly skilled self-employed people are often 'happy workers': quality of work is high and they are often more satisfied with their work. Lower skilled self-employed people and those forced to be self-employed are much less satisfied. For the self-employed, the work-home balance is often a problem, as are insecurity about the future, the sometimes low number of work providers, and the high degree of underinsurance for unemployment, occupational disability, and pension accrual. Both groups of flexible workers enjoy less protection than workers on fixed contracts, which is prompting a debate about how the disparities in protection between both groups (permanent and flexible) can be reduced.

Prognoses for the near future

The second research question is as follows: what are the possible effects of technological developments on future employment? The future is fundamentally unknown because it has yet to be made. It is therefore unsurprising that there are different visions and speculations about the future. In the current debate, attention focuses mainly on the extent to which robots and computers will lead to more or fewer jobs. This debate has been stoked by the investigators Frey & Osborne, who predict that in the next twenty years nearly half the current number of jobs in the US may be taken over by computers or robots. To ensure a good debate, it is important also to consider, alongside IT as a means of automating jobs, the role of IT in the creation of new jobs. Attention also needs to be paid to the economic, social, ethical and legal aspects involved in how IT influences work, how IT changes the organization of work, and finally the influence of IT on prosperity or, more accurately, the influence of IT on our capabilities for acquiring income and assets. These four issues still come up very little in public debate.

All these matters require consideration in order to gain a better understanding of the multi-layered and diverse influence of the IT revolution on work. IT allows the automation of existing jobs, but also affects in a complex fashion the way in which work practices and global value chains take shape. An example is the advent of platforms (such as Airbnb or Uber) that have been made possible by IT and which save capital and labour. IT also exerts a global, transformational impact: for instance, the breakthrough of the internet in the mid-nineties, the lowering of the costs of doing business internationally, and the formation of global value chains. For the coming years the further servitization of the manufacturing industry is being envisaged. This means that the service component of products is expected to increase. The challenge is for policy and politics to capitalize in a timely, intelligent manner on this whole IT-related set of developments. An understanding of prospects for action requires insights into how economic, social, ethical and legal aspects (may) help shape the relationship between IT and labour in the near future.

Policy options

The robot society as a positive prospect

There is a growing feeling that our technological society is again entering a new phase. We are currently confronted in all kinds of ways with new technological possibilities: from artificial intelligence and robots in healthcare to self-driving vehicles, sensor networks, big data, 3D printing, drones, and more. This broad development is captured in terms such as the Internet of Things and the Internet of Robotic Things. The big question now is how do we, as a society, handle this new phase of the IT revolution? History offers an answer to this question: techno-logy does not just happen to us, but takes shape in all kinds of social practices.

The Dutch response to the industrial revolution at the time was the formation of an industrial society, which was made possible by the appropriate technological and knowledge infrastructure, as well as by all kinds of social legislation. The Dutch response to the advent of the computer was the information society. During the recession of the 1970s, concerns grew about the loss of jobs as a result of automation. Those concerns prompted public debate and further research. A committee led by Professor G.W. Rathenau was established, among other things, to study the social consequences of microelectronics. In retrospect, that period of unrest, debate, and research has been crucial in creating awareness of the social importance of the IT revolution that had entered a new phase: a transition from the large mainframe computer to the small personal computer. The debate that started with the question of what small computers would mean for labour broadened into the question of how the computer society should look like. The mobilizing concept of the information society thus arose, which was deliberately used throughout Dutch society to free up money and energy for the application of computers.

The response to the advent of robotics and the robot internet may thus be something like the 'robot society'. The robot society is expressly enclosed in inverted commas because it is a concept that has yet to be fulfilled; it is, as it were, a mobilizing prospect. It is important that the Netherlands as a whole – from citizens, politicians, teachers and entrepreneurs to people in the manufacturing and creative industries and the services sector – becomes acquainted with the new technological options and visions in the field of IT, to enable us to appropriate these opportunities based on our own wishes and concerns. In many areas of society, active policy is required to shape a 'robot society' so that it can be a positive prospect for all Dutch people. In this context, three aspects deserve full attention: socially responsible innovation, training, and prosperity.

Socially responsible innovation

The historical perspective in this report shows that early investment in physical infrastructure and the building up of an adequate knowledge infrastructure are essential to reap the rewards of new, emerging general purpose technologies. Every age imposes its own demands on this. For example, during the first industrial revolution, the Dutch government, in collaboration with market players, invested heavily in transport systems, such as paved roads, canals, and railways, despite the poor state of the national public finances. In the second half of the nineteenth century, this facilitated, for instance, the modernization of the textile industry in Twente. The associated knowledge infrastructure also blossomed: engineering educational programmes and the national engineers' association were established. The creation of a sound electricity grid was crucial in the second industrial revolution. Private entrepreneurs and municipalities initially played a part in this, followed by the provincial and national authorities.

In the information age, computers in the 1950s were initially used for such things as administrative automation at insurers. The first professional associations in the sphere of automation also arose during that period. During the 1970s and 1980s, when the personal computer came into the picture, knowledge infrastructure entailed, for example, the setting-up of computer service centres, new professional associations, and the development of digital skills in the population through the promotion of computer use at home. The 1990s and the beginning of this century saw the advent of fast internet connections. Now, too, the question is about what role the government can play in boosting economic growth by encouraging technological development. Embracing the information revolution seems to be an important tool for the future because it contributes to productivity growth, even though the direction and choice of investments is a matter of debate. The following questions arise and will require further research in the future. Is the Netherlands investing enough in new technology? Why would more investment be desirable? How can digital start-ups be supported? What obstacles are there to the changes needed – and what part do our institutions (laws, rules, and application) play in this? How can public investment in technology and innovation contribute sustainably to a prosperous Netherlands?

Internationally, renewed attention for the manufacturing industry is currently perceptible, as illustrated by the Dutch *Smart Industry* intiative and German developments concerning the Industry 4.0 concept. The German discourse radiates a lot of positive energy, but it is also driven by anxiety that Germany is losing its global leadership in high-tech manufacturing to countries such as China and India. The traditional geographical distinction between low-value manufacturing there and high-value innovation here has become much less obvious. The smart factory has become the primary place where innovation on production processes and products takes place. The question for the future is thus where this smart factory will be located.[1] The clustering of innovative activities in certain regions is already apparent. More and more countries are actively striving to be or become an attractive location for enterprises and personnel.

In addition, more and more money is made from services linked to products. The digitization of industrial manufacturing processes and products is becoming increasingly dependent on close cooperation between industry and service providers, for example between the industrial and internet cultures. This means that more attention needs to be paid to encouraging cooperation between the industrial and services sector, and to the importance of innovation within the services sector.

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1 Where production ends up also has a geopolitical dimension: the battle between countries and regions for where the advantages and disadvantages of the IT revolution end up. This is prompting questions about Europe’s role: should the EU, for example, be more active in providing European alternatives to American or Chinese IT solutions?

Education and training

In the past, heavy investment in education has always made it possible to train people better and to meet changes in demand for skills (owing to the advent of technology). The 'race' between technology and education was won by education. Job polarization has become evident since the advent of the second machine age: middle-class jobs are under pressure. Looking ahead, it is expected that automation may affect all educational levels, in various ways. Even now, training and investment in education are cited as important policy tools for ensuring that people have the right skills for the work of the future. At the same time, it is uncertain what exactly that work – and the associated skills – will look like.

Investment in retraining and upskilling is needed to help surplus workers, including those with mid skilled jobs, find new work, and to shift the mid skilled segment as far as possible into the higher skilled segment. However, this is a slow and potential painful process for the groups affected. In the Netherlands, this process takes place chiefly via the influx of young people into the labour market. To match supply and demand as closely as possible, interaction between enterprises and education is important, for example in terms of involving enterprises in designing curricula, and in strategic relations between enterprises and educational establishments. New online matching services, such as LinkedIn, can play a part in bringing about a better, faster match between demand and supply. In addition, the emergence of Massive Open Online Courses (MOOCs) may help make higher education more accessible.
Investment in primary and secondary education is also important to equip children with skills for the future. This involves various generic skills: skills in which people differ from computers (working with new information, creativity, communication) or skills associated with flexibilization and a digitizing environment, such as metacognitive skills (e.g. learning how to learn), entrepreneurship, and e-skills (learning programming, 3D printing, etc.).

Prosperity

IT and automation have had an adverse impact on middle-class jobs. With broad application of the technologies of the second machine age, there is a real chance that inequality will grow in the future. That prompts the question of what we can do to ensure that the benefits of digitization are shared as widely as possible.

The government can, for example, create opportunities by encouraging more people to earn a living in the digital economy. Access to the internet is not sufficient for the effective use of ICT services, or for ensuring the ability to produce digital goods and services and thereby earn a living. This requires investing in digital skills. The development of inclusive technology also plays a part in this. This involves, among other things, technology for people with a disability and inclusive innovation: innovation for the benefit of principally poor population groups, and prioritizing the user and ease of use.

It is also important that the government offers protection. How can, for example, the interests of workers who have to contend with automation or platformization be safeguarded? This involves such things as a safe working environment, a safe number of working hours (to prevent excessive stress and exploitation), questions about adequate incomes to live on, and ensuring upskilling, as well as the safeguarding of privacy. Under a permanent employment contract, matters of this kind are generally well regulated. In the case of on-demand crowdsourcing of work, which generally does not involve an employer-employee relationship, but rather a client-contractor relationship, that is not the case. What rights, not only for low-skilled but also for high-skilled cognitive work, must be safeguarded? Is new social policy needed? Can workers' rights be designed and integrated into platforms?

Related to this is the policy option of regulating platforms – and thus newly emerging monopolies. Regulation is often still lacking at the present time. A debate has started in Europe on this, and the European Commission considers that regulation is needed to promote competition and prevent the development of monopolies. At the same time, it should be pointed out that these new business models also offer important opportunities for innovation and economic growth. It is therefore important to strike a good balance on this.

1 Introduction

Linda Kool, Rinie van Est, Ira van Keulen and

Arnoud van Waes

> *"For years we have studied the impact of digital technologies like computers, software, and communications networks, and we thought we had a decent understanding of their capabilities and limitations. But over the past few years, they started surprising us. Computers started diagnosing diseases, listening and speaking to us, and writing high-quality prose, while robots started scurrying around warehouses and driving cars with minimal or no guidance. Digital technologies had been laughably bad at a lot of these things for a long time – then they suddenly got very good."* – Brynjolfsson & McAfee (2014)

1.1 Smart machines

The debate about robotization and potential impacts on employment has flared up in the media, science, policy, and politics. For example, there are concerns about technological unemployment: in the future, will increasingly smarter technology (software and machines) replace labour on a massive scale? Others see opportunities: smart machines bring us more comfort, health, and economic growth. We can see examples of this ever smarter technology all around us: from highly automated factories in manufacturing, self-service tills, and software that predicts how busy the roads will be and by what time we need to leave home for an appointment, to legal software available free of charge for drawing up legal contracts.

Worries about technology are prompted by books such as *The Second Machine Age* van Brynjolfsson & McAfee (2014) or studies such as *The Future of Employment: How Susceptible Are Jobs to Computerization?* by the economists Frey & Osborne (2013) of the Oxford Martin School. Brynjolfsson & McAfee claim that, as a result of the information revolution, we are now entering a fundamentally different age. They distinguish between the first and the second machine age: central to the first age, which started in 1800, are machines that take over muscle power; the second age, which started in 1980, entails machines that take over thinking (computers, robots, internet, artificial intelligence) (see also Table 1 in Chapter 2). Brynjolfsson & McAfee expect these thinking machines to have a great impact on our lives and work. In their view, this impact poses great challenges for society in terms of employment and the distribution of costs and benefits of new technology.

The study by Frey & Osborne (2013) triggered international disquiet because it predicts that in the United States computers or robots will take over nearly half of all current jobs in the next twenty years. Deloitte (2014) projected Frey & Osborne's findings to the Dutch situation and came to similar conclusions. The Brussels think tank Bruegel (2014) calculated the figures for Europe as a whole; in the Netherlands, 49.5% of jobs are susceptible to automation, and this percentage is similar to that for other northern European countries (Belgium, Germany, France, the United Kingdom, Ireland, and Sweden) and the United States.

Besides concerns about the future of work, there are also worries about a phenomenon that has been clear from the statistics on the labour market for years: the increasing erosion of employment in moderately paid jobs, also known as 'job polarization'. Since the 1980s, increasing automation has been hitting not only the low-skilled but also chiefly medium-skilled workers. This entails 'routine cognitive work' (see for example Autor et al. 2003), work that can be successfully captured in rules and automated, as for example administrative work. Frey & Osborne think that in future computers may take over non-routine work, for example low-skilled work such as cleaning, and also high-skilled work such as that done by a surveyor or laboratory technician.

1.2 Concerns about technological unemployment

In late September 2014, Dutch Minister Asscher of Social Affairs and Employment, kicked off a broad public and political discussion of robots and their impact on employment. In his speech, Asscher referred both to the study by Frey & Osborne and to growing pressure on medium-skilled workers due to job polarization.[2] His speech took prospects of technological unemployment seriously. Seventy per cent of European citizens think that robots will eliminate their jobs (EC 2012). We can identify similar concerns at various times in history. At the beginning of the ICT revolution, initially in the 1960s and later in the 1980s, concerns arose about the implications of automation for employment (see Box 1). In 1979, the Rathenau Committee in the Netherlands investigated the social consequences of the microprocessor on behalf of the then Minister for Science Policy. The report by that committee then underpinned a targeted industrial policy and placed the information society on the social and political agenda.[3]

2 In the letter from Minister Asscher to the House of Representatives of the Dutch Parliament dated 19 December 2014, the Minister comments as follows on the report by Frey & Osborne: "As stated, technological development also offers opportunities, opportunities that are disregarded in the publication by Frey and Osborne." In this regard, he cited such aspects as the robotized production of shavers by Philips in the town of Drachten in the north-eastern Netherlands, which has created jobs for the region.

3 The study by Huppes focused closely on dialogue with and education of society in preparation for the advent of this technology (Veraart 2008).

During the same period, Tjerk Huppes (1980) conducted research for the Dutch Ministry of Social Affairs on the consequences for labour and employment, and warned that the introduction of microelectronics would lead to various adaptation problems in society; people would be unable to cope with the changes, drop out, and end up incapacitated for work.

During the Depression of the 1930s, John Maynard Keynes (1930, p. 3) used the term ‘technological unemployment’ for the first time: “Unemployment due to our discovery of means of economizing the use of labour outrunning the pace at which we can find new uses for labour.” He added that this would be only a temporary adaptation period; new jobs would arise again. Since the first industrial revolution, this has been the conventional picture of technological development: technology destroys jobs in old sectors, but creates new jobs in new sectors to replace them. Thus, the coalman has vanished, as too has the telegram messenger, but the IT revolution has brought new jobs such as the web designer and data scientist. In broad terms, in many Western economies, including the Netherlands, the twentieth century witnessed a shift from work in agriculture to work in the industrial sector, and thence to work in the services sector.

Current debate revolves around whether this will happen again this time – in the age of smart machines – or whether things are now different. What tasks can smart machines take over, and where will people and machines complement one another? How is the organization of production and labour changing? Take, for example, the advent of platforms such as Uber or Airbnb, which have grown into major economic players with relatively little labour and capital. What does that mean for the distribution of the costs and benefits of technological change? Are certain groups on the labour market more vulnerable than others? Can well-known policy measures, such as education and training, redistribution of income, and job security arrangements, now also help prevent potential adverse effects? Or are developments now proceeding more quickly, differently, and with greater consequences for various groups on the labour market? Do they call for more innovative policy options?

Experts are divided in their opinions. Pew Research, an independent opinion polling agency in the USA, has surveyed 2,000 experts in artificial intelligence, robotics, and economics about the role of automation leading up to 2025 (Pew Research 2014). Although their forecasts about the evolution of technology largely agree, experts are deeply divided about how robotization will affect the economy and employment in the coming decade. Of these experts, 52% predict an optimistic path for the future, whereas 48% are worried about the future. Concern among citizens and the dissension among experts call for open and fundamental thinking about the significance of innovation for the future of the Dutch economy and labour market. This study is intended to contribute to such thinking.

Box 1 Concerns about the impact of automation in previous decades

There have always been concerns about the impact of automation on employment. These were generally connected with the loss of jobs due to new technology, concerns that are again finding expression in the current public debate. The prevailing view within science has hitherto been that, since the first industrial revolution, technology indeed destroys jobs in 'old' sectors, but creates new jobs in new sectors to replace them.

In 1955 in the **United States**, the Joint Economic Committee (JEC) of the United States Congress held lengthy hearings on the consequences of "automation and push-button factories" for the American labour market.[4] In 1961, President John F. Kennedy established the Office of Automation & Manpower. This agency was designed to study "the major domestic challenge of the Sixties: to maintain full employment at a time when automation, of course, is replacing men." Three years later, in 1964, President Johnson set up the Blue Ribbon National Commission on Technology, Automation and Economic Progress. That same year, a group of scientists and social organizations published an open letter on the 'triple revolution', which included the following passage:

"A new era of production has begun. Its principles of organization are as different from those of the industrial era as those of the industrial era were different from the agricultural. The cybernation revolution has been brought about by the combination of the computer and the automated self-regulating machine. This results in a system of almost unlimited productive capacity which requires progressively less human labor. Cybernation is already reorganizing the economic and social system to meet its own needs."[5]

In the Netherlands, Premier Joop den Uyl indicated in 1979 that he was worried about the impact of the microcomputer on the Dutch labour market. In an article in the publication *Informatie*, he expressed his thoughts as follows: "The question nevertheless arises as to why there is now so much concern about chips. The answer is obvious: because there is widespread, persistent unemployment, and the fear must be that the introduction of microcomputers will make this worse" (Den Uyl 1979). One year earlier, the Dutch Government – in the person of

4 http://www.dol.gov/dol/aboutdol/history/mono-mdtatext.htm
5 http://www.futuristspeaker.com/2014/08/when-it-comes-to-jobs-why-is-this-time-different

Science Minister Peijenburg – had established the Rathenau Committee[6], with a remit that included investigating the social consequences of emerging technologies, notably microprocessor technology. Would the advent of microelectronics merely lead to higher unemployment in the Netherlands or would new (economic) opportunities arise? According to then Director-General Egbert Spiegel, the report came as a bombshell: "It was also unique. Its broad and thorough analysis clearly outlined the opportunities and threats of new technology. It also made it clear that we had to develop an effective technology policy quickly if we wanted to make up the leeway" (Alphen & Nebbeling 2011).

1.3 Aim of the study

The Standing Committee for Social Affairs and Employment (SAE) asked the Rathenau Instituut to conduct a short-term study (lasting three to four months) to explore the latest scientific findings on the impact of technological developments on employment. A number of bodies, including bodies with an advisory role, are currently preparing various reports in which technology and work are of key importance; these bodies include the Netherlands Scientific Council for Government Policy (WRR), the Social and Economic Council of the Netherlands (SER), KVS[7] and the Netherlands Bureau for Economic Policy Analysis (CPB).[8] The present study also serves to prepare for the political debates on these forthcoming reports.

The aim of this study is to map out current scientific knowledge concerning the complex relationship between technological developments and labour in connection with the above-mentioned contextual factors. Where is there scientific consensus, where is there dissensus, and where are there gaps in the scientific knowledge? Can science provide a shared fund of knowledge to underpin the societal and political debate?

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6 Gerhart Rathenau – as former Director of NatLab – chaired the Committee.

7 *Koninklijke Vereniging voor de Staathuishoudkunde*. (Dutch Royal Society for Economics).

8 The Future of Work project is taking place at WRR. This aims to "map out crucial labour market developments in the digital revolution and the flexibilization of labour relations, and their social and economic significance. And what do these developments require from policy?" (www.wrr.nl). The report is expected to be published in 2016. At the beginning of October 2014, Minister Asscher asked SER to examine the impact of technological developments such as robotization on the labour market. SER is also required to advise on the skills that people will need in future and what this means for education. Minister Asscher has additionally enlisted the services of CPB, which he asked to "conduct follow-up research on the potential impact of technological development on the labour market" (Parliamentary Papers II 2014/2015, 29 544 number 281; letter from the Minister for Social Affairs and Employment concerning the impact of technological developments on the labour market, 19 December 2014).

1.4 Research questions

The key question facing the Standing Committee for Social Affairs and Employment is as follows: what current[9] scientific knowledge is there on the impact of technological developments on employment?[10] Subquestions concern what relevant, current knowledge is available on:

1. the influence of technological developments (mechanization, automation, and so on) on employment in the past.
2. the potential impact of technological developments on future employment.
3. scope for responding, via policy, to future effects on employment, for example by means of education and training.

The relationship between technological development and employment is highly complex. Scientific research on these questions is going on in many different areas, from the perspective of different scientific disciplines, and based on different levels of aggregation. Each approach yields a different kind of knowledge. In the present report, the Rathenau Instituut highlights the main insights from science as clearly as possible with the aim of allowing effective and currently informed debate.

The study consists of literature review, media analysis of the policy options, as referred to by experts in the public debate (Annex 6), and interviews with scientific experts (for a list of experts consulted, see Annex 1). The reports appear as brief 'intermezzi' inserted before each chapter. In the review of the literature, we have focused as far as possible on the most topical and most frequently cited and recent publications. The aim of the interviews is a) to verify whether relevant literature has been included in the review of the literature, and b) to be able to assess the scientific value of the literature found and set out policy options in concrete detail. The policy options are not concrete policy *recommendations*, but indicate directions where government can play a part. Further reflection on and analysis of these options is needed to come up with concrete policy recommendations.

The report inevitably contains interpretations by the authors based on the above material. In accordance with the Rathenau Instituut's quality procedures, the report has been submitted for review to a researcher not involved in the study. In drawing up this report, the Rathenau Instituut worked together with the Foundation for the History of Technology (SHT) and the Netherlands Organisation for Applied Scientific Research (TNO).

9 Over the last ten years.

10 Parliamentary Papers II 2014/205, 29 544, number 583. Letter from the Praesidium concerning labour market policy.

Robert Went, an economist at the Scientific Council for Government Policy (WRR), acted as an external advisor on the study, but responsibility for the findings of this report lies with the Rathenau Instituut.

1.5 Approach

To answer the questions of the Standing Committee for Social Affairs and Employment, we have structured our study by two main themes. These fall under the Committee's central question: what is the impact of technological changes on employment? The first theme focuses on the first part of this question: which technology and technological revolutions are we actually referring to? In this regard, we put technology in a historical and social context. At the explicit request of the supervisory committee associated with the Standing Committee for Social Affairs and Employment, we do not confine the past to the IT revolution, but take a longer historical perspective. The second theme examines the second part of the main question: the relationship between technology and labour. We deal with both themes at greater length in the sections below.

Technology in a historical and social context

Recognition of the impact of technology on society is ubiquitous within society. Often, however, this finds expression in the idea that technology determines the shaping of society. This technologically deterministic view does not do justice to the complex relationship and interaction between technology and social, economic, and political processes. In this study, we assume that social, cultural and economic processes and technology mutually influence each other (see, for example, Misa et al. 2003). This interaction, also known as 'co-construction', indicates that existing views, regulations, institutions, and infrastructure exert an influence on the development and application of technology, and that technology in turn influences these views, regulations, institutions, and infrastructure.

From the perspective of the history of technology, there are often said to have been three industrial revolutions, namely: the introduction of steam, electricity, and information technology (IT). The distinction between the first and second machine age is important in the debate about technology and labour (Brynjolfsson & McAfee 2014). The first machine age encompasses the first and second industrial revolutions, and consists chiefly of machines that take over muscle power. The third industrial revolution – the IT revolution – ushers in the second machine age, in which machines also take over thinking (see also Annex 2).

The question that then arises is what lessons we can draw from the first machine age with regard to the relationship between technology and employment in the second machine age.[11]

The information revolution

The information revolution consists of convergence between four different technologies. The first of these is the digitization of production processes, entailing the merging of mechanical engineering and electronics (mechatronics). The advent of automation and robots has radically transformed work in countless factories and will carry on doing so in the years to come. The second convergence concerns the digitization of communication processes. This entails the merging of information and communication technologies, hence 'ICT'. In the 1990s, this sparked the advent of the internet. Thirdly, there is a convergence between the internet and physical 'smart' objects such as cars, domestic appliances, and robots, known as the Internet of Things. A fourth form of convergence is what is known as NBIC convergence[12]: an ever stronger interconnectedness of the natural sciences (nanotechnology and information technology) and the life sciences (biotechnology and cognitive sciences).

The information revolution (IT revolution) is central to this study. Wherever this study refers to the IT revolution, we are alluding to the four convergences mentioned above. However, not all scholars whose articles have been scrutinized for this study do this. They usually refer to the impact of ICT (and not IT), particularly where the recent past is concerned.

Relationship between technology and employment

For the second theme, we look more closely at the relationship between technological change and employment. Two frequently heard, opposing views of this relationship form our starting point here. According to one view, technological innovation leads to economic growth, jobs growth, and an acceptable distribution of prosperity: technological innovation leads to greater productivity and cheaper products, in turn bringing about higher consumption and thus growth in the market and more jobs. According to the opposing view, technological innovation leads to greater productivity, but technology replaces labour

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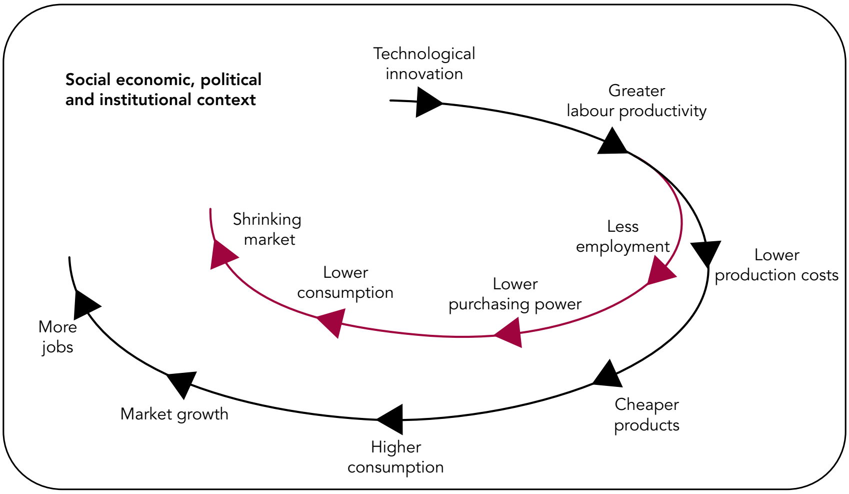
11 The first industrial revolution between 1820 and 1870 was based on the steam engine, while the second industrial revolution was based on the electric motor and the internal combustion engine. In the 1940s Mandel (1968, p. 605) saw a third industrial revolution coming, based on nuclear energy and the use of electronic machines. This terminology is used by others in various ways. Over time, the third industrial revolution has increasingly been used to refer to the IT revolution, in other words the age in which the computer is of central importance. Recently, there has been more of a focus on a 'new' wave of technology in which, as mentioned, robots, artificial intelligence, sensor networks, and big data analysis will be of central importance. Some also describe this as the fourth industrial revolution, Industry 4.0, or smart industry (FME 2014; Bloem et al. 2014).

12 The convergence between nanotechnology, biotechnology, information technology, and cognitive sciences.

on a large scale, which means that innovation leads to less work and a lopsided distribution of prosperity. This in turn results in lower purchasing power and consumption, and hence dwindling profits and markets (see Figure 1).

Figure 1 Vision of technology and labour: more or fewer jobs



Rathenau Instituut

History is characterized by many periods of economic and jobs growth. It also shows us that these growth spurts do not come about 'automatically', but arise in part from socioeconomic, political, and institutional reforms or choices (the unremitting interaction between technology and society that we alluded to earlier is evident here as well). An example is the deep economic crisis that occurred in the 1930s with rising unemployment, falling purchasing power and consumption, and thus dwindling profits and shrinking markets. It was principally the Second World War that necessitated a lot of jobs, and in the USA it was the 'New Deal' that helped put the economy back on its feet again.

The growth spurts in both views are thus based on a number of assumptions. These assumptions form the research framework of this study, and underpin our analysis of both views to find out:

1. What characterizes current technological innovations?
2. What is known about the relationship between IT and productivity, and specifically labour productivity?
3. What is known about the relationship between IT and the loss/creation of jobs?
4. What is known about the relationship between IT and prosperity?

What does the broader socioeconomic, political and institutional context look like? What, for example, is the role and power of trade unions, employers, and government? How is social acceptance of technological innovation developing?

We deal with these questions in greater detail in various chapters (see section 1.6, Chapter guide). We look first at the past, then at the future, and after that we discuss what policy options are put forward. The context is addressed in all chapters, but is chiefly shaped by the historical perspective, as described above.

1.6 Chapter guide

Part 1: Technology in a historical and social context

Technological innovation

In Chapter 2, Rinie van Est (Rathenau Instituut) describes the technical and organizational characteristics of current technological innovations.Technological changes have brought about a steady increase in the rationalization of production and work processes, and later also consumption. With the rise of scientific management, or Taylorism, in the nineteenth century the craft factory was redesigned as 'a big efficient machine'. In the 1980s, the advent of IT meant that the service sector also came within the grasp of industrial efficiency thinking: digital Taylorism reorganized the service sector, splitting it where possible into simple subtasks amenable to outsourcing, offshoring, reshoring, or automation. In this context, steadily increasing optimization of the use of labour takes place. The internet currently allows the advent of digital platforms, which can operate with relatively little capital and labour.

In Chapter 3, Jan Korsten, Harry Lintsen, and Johan Schot (Foundation for the History of Technology, SHT) look at how technological innovation in the Netherlands has developed since the beginning of the industrial revolution. They describe three examples based on three technological revolutions: the introduction of steam, electricity, and IT. In so doing, they show what factors, including contextual factors, played a role as barriers and drivers, and how various players acted to prevent adverse effects and promote positive ones. In their account, the authors also address the role that government played in this. These chapters take a long-term perspective. The authors describe how, from the beginning of the industrial revolution, technological innovation has influenced the organization of labour in the Netherlands. Their prime aim is to shed light on the characteristics of the current IT revolution. The following three chapters cover a shorter time span and focus in particular on the information revolution.

Part 2: Relationship between technology and employment

IT and labour productivity

In Chapter 4, Frans van der Zee (Netherlands Organisation for Applied Scientific Research, TNO) examines the relationship between technological innovation, productivity growth, and economic growth. What concepts and indicators are used to map out this relationship, and what are their advantages and disadvantages? What contribution has the IT revolution made to productivity growth in the past 15-20 years? Van der Zee also discusses the different conceptions of, and divergent underlying arguments for, the relationship between technological innovation, productivity growth, and jobs growth for the future. Are we heading for a future of secular stagnation (zero growth), or conversely one of unprecedented growth, notably productivity growth? And what should the Netherlands focus on in the coming years to avoid falling by the wayside?

Automation and job creation

In Chapter 5, Linda Kool (Rathenau Instituut) discusses the impact of the IT revolution on the labour market. Which labour market groups does automation affect? What is known about potential new jobs created by IT? Since the 1980s it has become apparent that the increasing automation of routine cognitive work is also affecting people with medium skill levels. Expectations for the future are uncertain. Some people assume that smart software and machines will increasingly be able to take over non-routine work, whereas others are more sceptical– of this will happen, and about the pace at which this will happen. Kool discusses the various policy options cited in relation to job polarization, with the emphasis being primarily on education and training.

IT and prosperity

In Chapter 6, Govert Gijsbers (TNO) examines the relationship between IT and prosperity. The impact of IT on productivity also influences other economic developments, for instance in the form of lower production costs or the evolution of wages, and thus helps shape the evolution of purchasing power and economic growth. This chapter therefore looks at what is known about the 'tail end' of the spurts referred to above (Figure 2). What patterns in the distribution of incomes and wealth have emerged in the last few decades? What is the role of technology in this? How do digitization and increasing flexibilization affect job security and job quality? Are these new forms of inequality? Gijsbers first covers changes in the distribution between labour and capital (labour income share). IT plays a role in the decline of labour as a share of national income, but so too do globalization, the waning power of the trade unions, and increasing liberalization of the labour market. Gijsbers then discusses the distribution of incomes and wealth. He also covers qualitative aspects of prosperity: what is known about the quality and security of labour in relation to the advent of IT? The number of flexible working contracts and self-employed people is growing; academics relate this in part to these technological developments. Lastly, Gijsbers discusses various policy options cited in this connection.

Part 3: Summary, findings, and conclusions

The robot society as a mobilizing prospect

In Chapter 7, Rinie van Est, Linda Kool, and Frans Brom (Rathenau Instituut) look back on the three secondary questions posed by the Standing Committee for Social Affairs and Employment: what relevant and current scientific knowledge is available on the IT revolution and employment in the past, what are the potential future effects, and what policy options are cited? The chapter summarizes the findings of the report: on what issues is there scientific consensus (broadly speaking), and where do opinions diverge? Opinions diverge notably on the future, since the latter remains fundamentally unknown. Van Est and others allude to the findings and see the concept of the 'robot society' as an important mobilizing force for acquainting society – in the form of citizens, enterprises, politicians, civil society – with new technological capabilities and involving them in considering how this robot society can be shaped.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1 Technology in a historical and social context

Intermezzo

Interview with
Sabine Pfeiffer,
University of Hohenheim

Intermezzo

"Employees are morphing into self-employed people"

From the outside, German industry looks like it can easily handle technological innovation, but behind the scenes there is great insecurity, claims Sabine Pfeiffer, a professor at the University of Hohenheim, near Stuttgart. By approaching the changes proactively, we can stay on top – that's what the public line is, according to this German labour and industrial sociologist. Secretly, however, there is a fear that Germany will, despite frantic efforts to manage the process as effectively as possible, be toppled from its leading position in industry. "But nobody has empirical proof which way it will go."

These concerns are not entirely unfounded, asserts Pfeiffer, who paints a mixed picture. A clear majority of the German working population has followed a dual learning pathway, which means that the medium-skilled are less vulnerable as a group to the consequences of technological innovation than in countries like the United States. The problem, according to Pfeiffer, is the lopsided focus of policymakers on the industrial sector, for example on the processing and automotive industries. Production there is already highly automated. "Politicians overlook what is happening in services, particularly in logistics. The changes there will be much more dramatic."

In addition, the approach to implementing new technology is too top-down. Involving workers earlier and more closely in processes of change can not only improve working conditions but it may also allow more productive deployment of technology, explains Pfeiffer.

Relocating jobs (for example, in the IT sector) to low-wage countries has become relatively easy in recent years. This forms an important part of companies' strategy to become increasingly independent of workers, and also applies increasingly to high-skilled work. But this is not true for all jobs in the industrial sector, in the German professor's view. After all, machines and goods are also involved. True, you can set up a machine in a country like China. "But if there's a technical problem, or a new component has to be installed, you can't solve that over the internet." Pfeiffer expects that highly skilled workers will always be needed near the production process. But the way they are used is certainly subject to change. More and more frequently, people are being used only where the business needs them; what is known in Germany as 'crowdworking'. "Employees are morphing into self-employed people. The client-contractor relationship is taking the place of the employer-employee relationship. Businesses are now experimenting with how far (in which production processes) they can deploy this flexible model."

For the trade unions, which are traditionally strong in Germany, the flexibilization of organizations is making it more and more difficult to protect workers' interests. Here, too, Pfeiffer sees a difference between the message being given to the outside world and what is actually said behind the scenes. The unions are trying to adopt a constructive attitude and visibly cooperate in giving this development a human face. "But when I talk to them informally, most are more sceptical and critical." That is not naive; they have little choice: an overcritical attitude would spell an end to them being invited to the negotiating table, according to Pfeiffer.

Pfeiffer would love things to be different but in her eyes global capitalism is the most realistic scenario for the future. Pfeiffer's view is that if society genuinely wanted a sharing economy, it would already have happened. After all, the internet makes this much easier. "I would love [the American economist Jeremy] Rifkin to be right with his vison of 'collaborative commons,' but I don't see it happening." In Pfeiffer's opinion, the changes on the labour market and the weakened position of the trade unions are an inducement to think about ways of guaranteeing the fundamental rights of workers. One example of this is ensuring that someone else takes over a given task after twelve hours because it has been agreed worldwide that nobody is allowed to work more than twelve hours a day. We should engineer this protection into the platforms.

To be able to direct the impact of technological innovation on the labour market in the right direction, better and more usable information is needed quickly, claims Pfeiffer. Although information is available, it is too general and outdated, at any rate given the speed with which changes are now taking place, she emphasizes. "Our main surveys contain questions such as: do you work with a PC, and if so, how often?" There is insufficient awareness of things like working conditions, what exactly people are doing, and what level of automation is used in this connection. "We don't even know what is happening now, so how can we make predictions about the future?"

2 The transformative power of information technology[13]

Rinie van Est

> *"Uber, the world's largest taxi company, owns no vehicles. Facebook, the world's most popular media owner, creates no content. Alibaba, the most valuable retailer, has no inventory. And Airbnb, the world's largest accommodation provider, owns no real estate. Something interesting is happening."* – Goodwin (2015)

According to Brynjolfsson & McAfee (2014), we are currently living in the second machine age, the age of the thinking machine, also known as the IT age. This age is characterized by the rationalization and automation of physical <u>and</u> cognitive labour, within both manufacturing and the services sector. Digitization and the internet allow new ways of organizing production, labour, and consumption. The above pronouncement by Goodwin (2014) illustrates this aptly.

Section 2.1 describes a number of characteristic trends of the IT revolution, such as compression and convergence. In this connection, this section also dwells at length on one of the convergences of IT that is currently attracting considerable attention: the Internet of Things (IoT). A final trend is the informatization of our world view, in which programmability and manipulability are of key importance.

Technological revolutions are more than a collection of technological inventions. They entail new economic, social, and political relationships. Because technology obtains its transformative power in interaction with social processes, section 2.2 goes on to describe how IT allows new ways of organizing production, labour, and consumption. That section makes a comparison with the first machine age, in which industrialization, rationalization, and mechanization of physical work were of central importance. Finally, section 2.3 sets out the main findings on the IT revolution and the transformations taking place within it.

This chapter does not provide a comprehensive account but is intended to give the reader a conceptual framework for examining this IT revolution from a technological, economic, and organizational perspective. In this way, this chapter is designed to show why the interesting developments raised by Goodwin are taking place right now.

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13 This title refers directly to the theme of the *Jaarboek ICT en Samenleving 2012* (Prins et al. 2012).

2.1 Characteristic trends of the IT revolution

Information technology (IT) is exerting a strong influence on the present. IT is – just like steam or electricity in the first machine age – being used in countless ways. Bresnahan and Trajtenberg (1995) speak of a 'general purpose technology' which not only allows many new products but in the long run affects numerous social processes. IT is ubiquitous in our society and is steadily evolving. This section outlines the dynamics of IT on the basis of various phenomena: compression, convergence, hyperconnectivity (Oortmerssen 2012), and informatization of our world view.

Compression (miniaturization)

The transistor is the fundamental building block of every chip and thus underpins every IT application. In the past fifty years, the number of transistors on a chip has doubled roughly every eighteen months to two years. This trend for miniaturization or compression is called Moore's Law, and in the last few decades it has meant that computers have steadily become smaller, more powerful, and more affordable.

In the 1970s, large mainframe computers were affordable only to governments and companies, and only computer experts could operate them. Now billions of people go around with smartphones. Other devices have also shrunk in size. Accelerometers started off as big as a shoebox and weighed a kilogram. Now, they are a couple of cubic millimetres in size and are present in every smartphone (to determine whether the user is shaking it, for example in order to shuffle the play list). Data storage has also changed radically (Poort 2014). At the end of the 1980s, CD burners cost around a hundred thousand dollars, but by the mid-1990s they had become affordable to consumers. The USB stick appeared on the market at the beginning of the new millennium; since 2008, Dropbox has been available and we can store our data in the cloud via the internet. The long-term exponential growth of computational power, storage space, and computation speed has significantly expanded the possible applications of IT. Examples include IT hardware products such as laptops, smartphones, digital cameras, payment terminals, and 3D printers, and software for applications such as design, social media, word processing, e-mail, search engines, and navigation.

Miniaturization is just one of the possible improvements of the chip. Numerous other challenges still need to be met, for example in terms of energy saving or the production of complex chips. This entails microelectromechanical systems (MEMS), such as 'labs-on-a-chip' or accelerometers.

Box 2 Limits to Moore's Law

Moore's Law is based on a prediction made in 1965 by Gordon Moore, one of the founders of the technology firm Intel. Moore predicted that the number of transistors on a microchip, and thus the computational power of computers, would double every two years, while costs would remain the same. Fifty years on, it turns out that Moore's Law still holds true. This is not a literal law, but an expectation of the speed of technological development that the global semiconductor industry aims to achieve through voluntary technological arrangements.[14] There is thus no certainty about how quickly this technical advance will proceed in future.

Although continuous miniaturization of chips will clearly run up against physical barriers one day, the electronics industry assumes that Moore's Law will continue to hold over the next decade (IEEE Spectrum 2015). After those ten years, the question will be whether even more transistors can be put on a chip. Transistors are currently around 14 nanometres in size (a nanometre is one billionth of a metre), and Intel predicts that they can get down to only 5 nanometres; after that, a switch may be made to 3D chips (stacking, in other words). At the same time, the smaller they become, the more expensive transistors are. Moore's Law may thus prove not to hold in future because production costs will rocket. Or else new technologies will emerge as a substitute, for example chips based no longer on silicon, but on completely different optical, nano or even biological principles. If this happens, the question is whether the new technology – which must carry on bearing the Moore's Law prediction – will be commercially available in time (and thus affordable). It may therefore be that a period of slow innovation and growth will dawn in ten years (Atkinson 2004). But it may also be that the speed of the processor (and thus the microchips) in a computer will become less relevant in a few years owing to the advent of cloud computing. Moore's Law may therefore become irrelevant in the future.[15]

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14 This concerns the International Technology Roadmap for Semiconductors (see http://www. itrs. net/).
15 http://www.economist.com/blogs/economist-explains/2015/04/economist-explains-17

Convergence
In *The Rise of the Network Society,* Castells (1996) asserts that technological convergence is a major feature of the information revolution. In other words, IT blends with pre-existing technologies and processes. We can identify four crucial convergences here (see Table 1).

A first form of convergence is the digitization of production processes. Here, mechanical engineering and electronics combine in mechatronics. The advent of automation and robots has radically transformed work in countless factories, and will carry on doing so in the years to come.

The second form of convergence is the digitization of communication processes. Here, information and communication technologies combine in what is referred to as 'ICT'. In the 1990s, this convergence led to the emergence of the internet. Over the years, the internet has developed from an information source into an interactive medium for users. The advent of mobile technology, notably the smartphone, has enabled nearly two billion people worldwide to use a huge number of mobile internet services.

In many areas – such as music, media, retailing, and the hotel trade – the internet has drastically transfigured relations between business and the consumer, and is continuing to do so. According to many IT firms and authorities, the Internet of Things (also known as the industrial internet) will come to full fruition over the next ten to twenty years. The third convergence is therefore a far-reaching one, the convergence of the internet with the physical world. Physical products will be assigned an internet address (IP address) and may be expanded with sensors, computational power, and communication facilities. This enables the linking of digital services to products. In this way, the birth of the Internet of Things transforms the physical world into one huge information system.

A fourth form of convergence is 'NBIC convergence': an ever closer interconnectedness between natural sciences (nanotechnology and information technology) and life sciences (biotechnology and cognitive technology) (Est 2014). This convergence manifests itself in two trends: 'biology increasingly becoming technology', and 'technology increasingly becoming biology'. The first trend means that living systems are increasingly seen as engineerable. Examples are genetically modified bulls or deep brain stimulation to reduce the severe tremor of Parkinson's patients. In the second trend, that of 'technology becoming biology', technologists draw their inspiration from biology in an approach known as *biomimetics*. Examples are artefacts such as self-cleaning windows (based on the lotus leaf) and social robots (based on the imitation of social human behaviour).

Table 1 Overview of four crucial IT convergences.

Convergence	Areas converging	Digitization of
Mechatronics (robotics)	Mechanical engineering & electronics	Production processes
ICT (including internet and mobile telephony)	IT & communication technology	Information and communication processes
Internet of Things (info and nano)	Internet & physical world (convergence of bits with atoms)	Value chains
NBIC (nano, bio, info and cogno) convergence	IT and biology	Life

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Hyperconnectivity and the Internet of Things
The Internet of Things, the third form of convergence as described above, not only enables people to communicate with other people but also allows people to communicate with machines, and machines with other machines (M2M): from watches and keys to shoes, cars, and buildings. To use its technical name, this means hyperconnectivity. This is conditional on such products having an IP address and being smart: they must have sensors and computational power and, where appropriate, have capabilities to take action. Examples are smart meters enabling an energy company to read electricity consumption remotely, smart shoes that share your sporting performance with other runners, and cooperative cars.

This development provides scope for adding all kinds of digital services to physical products (Fleisch et al. 2014). Furthermore, smart devices of this kind are enabling the internet to grow vigorously, giving it, as it were, 'senses' (sensors) and 'hands and feet' (actuators). This has led to the phrase 'Internet of Robotic Things' and the trend of 'Internet to Robotics' (Asada et al. 2009). Robots are thus on the one hand an important link in the Internet of Things, while on the other hand the internet is assuming the features of a gigantic robotic system (Royakkers & Van Est 2015).

The Internet of Things is still in its infancy, similar to the internet of the late 1990s. Various thinkers, major IT concerns (such as GE, Cisco, Intel, Siemens, and the Chinese company Huawei), and governments are supporting this development. Rifkin believes (2014) that the Internet of Things will transform economies and societies completely. Digitization and the internet reduce the costs of making and disseminating an extra e-book, music album, or film virtually to nil. This Internet of Things will lead to the 'marginal costs' of numerous physical products, such as the production of an extra kilowatt hour, falling virtually to zero (Rifkin 2014). This vision of the future, which is disruptive but nevertheless attractive to many, is exerting considerable influence on both European and Chinese policy. In Germany, the Internet of Things trend is mainly discussed under the heading '*Industrie 4.0*' (Kagermann et al. 2013), while in the Netherlands this vision of the future is called 'smart industry' (FME et al. 2014). General Electric talks about the 'Industrial Internet' (Evans & Annunziata 2012) and sees this as the merging of the industrial revolution (machinery, physical infrastructure) and the internet revolution (smart devices, networks, and decision-making). This offers up all kinds of possibilities. A train manufacturer could decide to fit all the moving parts on its trains with sensors in order to monitor its fleet of trains via the internet and thereby lower maintenance costs. This would then create a 'smart fleet of trains'. Other visions of the future that have been put forward under the title of 'smart' and the Internet of Things include the following: smart energy networks, smart mobility (including self-driving cars), smart homes, digital oil extraction, robot mining, smart farming, and smart cities. IBM even talks about 'building a smarter planet'.[16] Boosting the efficiency of work by the deployment of data collection and analytical technologies is one of the features central to all these new technological systems.

It is uncertain in what way or how quickly such visions of the future will become reality. According to a survey by the World Economic Forum (WEF 2015, p. 8), three quarters of respondents think that the Internet of Things will have disruptive consequences for their industry within only five years. Deutsche Bank thinks that it will take ten years for the market impact of the Internet of Things to become genuinely tangible (Heng 2014, p.12). First of all, many entrepreneurs are still unfamiliar with this new development. In addition, a host of uncertainties and challenges lie ahead (see, for example: Heng 2014; Fleisch et al. 2014; Broadbent et al. 2013). These include the following questions: What will be the business models? When will the mobile network be cheap and fast enough (the 5G network required will not be operational until after 2020)? How can a secure Internet of Things be ensured? How will industrial and internet culture interact? How will the battle for big data (the new gold) play out? And how can the privacy of customers be safeguarded?

Informational world view

A fourth characteristic phenomenon of the IT revolution is the underlying informational world view. Programmability and manipulability are central to this world view, this 'cybernetic' vision (De Mul 1999). Within cybernetics, it is possible to describe mechanical, organic, cognitive, and social processes as information processes, in digital terms. If the simulation of processes via computer programs is achieved, it will also be possible to imitate or manipulate then. An example is digital photography (Ismail et al. 2014, pp. 28-29). Once we have photographs in digital form, we can process them digitally (as

16 http://www.ibm.com/smarterplanet/nl/nl/

with photoshopping or tagging via facial recognition technology). However, a great deal more is changing with the digitization of photographs. Photographs become detached from photographic paper and can easily travel between the virtual and the physical world. The marginal costs of making an extra photograph and the costs of storing and sharing photographs fall to virtually zero. Digital photography has had serious consequences for all parts of the photographic market: cameras, film rolls, developing processes, distribution, marketing, storage, and the cultural and social importance of photography.

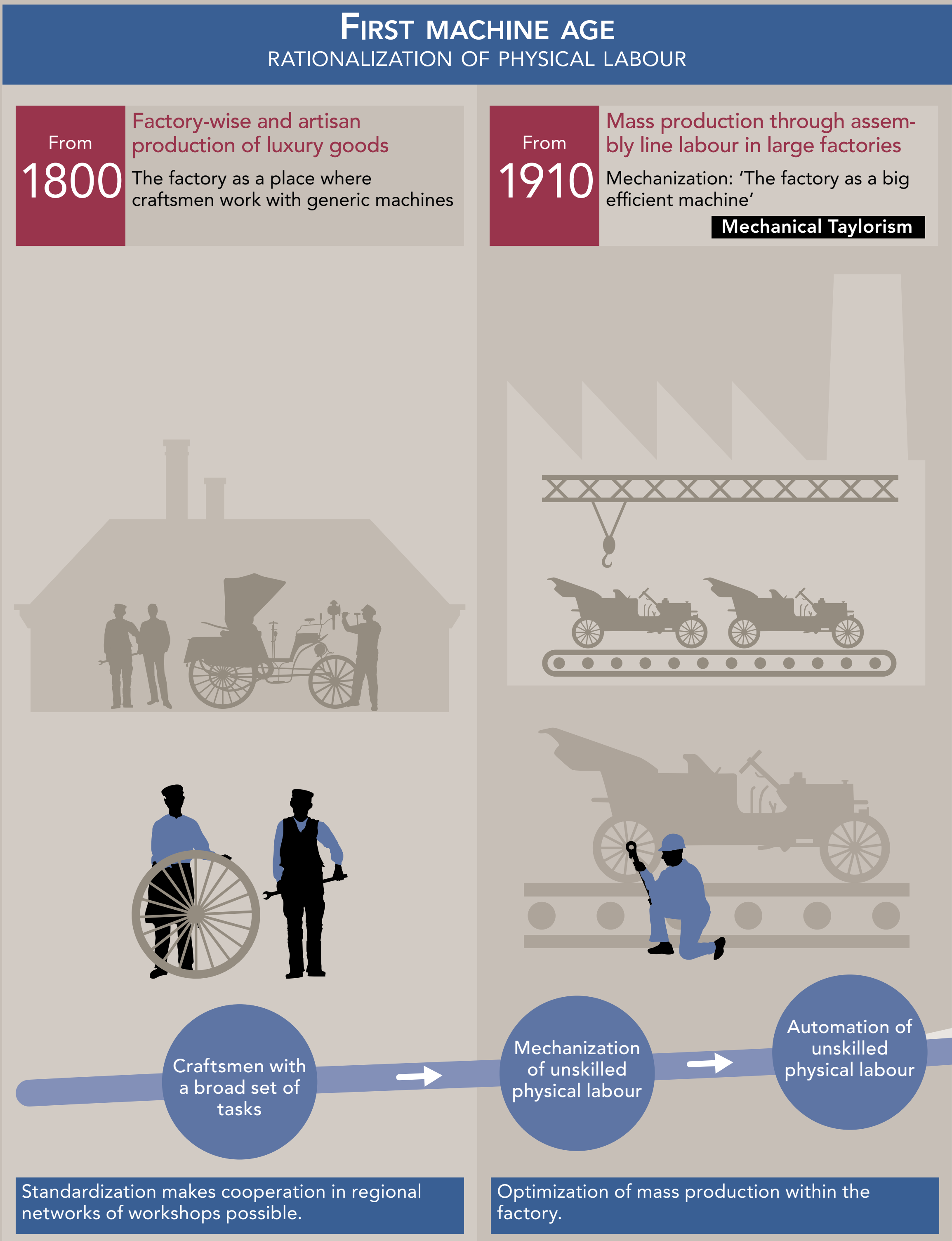
IT as an 'enabling' technology makes it possible to digitize products and processes. Banks digitize the movements of money, Google digitizes the provision of information, Facebook and LinkedIn digitize our social interaction, and Uber digitizes contact between the taxi driver and taxi passenger. These examples show that digitization can have huge consequences for the way in which we organize social and economic processes. IT is therefore regularly characterized as a disruptive, innovative force (Christensen 1997). Rifkin (2014) even foresees the end of our capitalist society: in the 'zero marginal cost society' that is being born, the market will become steadily less important (see also Chapter 4).

2.2 Organizational characteristics of the IT revolution

The IT revolution allows new ways of organizing production, labour, and consumption. This section compares the organizational changes resulting from the IT revolution in the current second machine age, in which machines provide thinking power, with the organizational changes in the first machine age, in which machines provided muscle power (Brynjolfsson & McAfee 2014). In so doing, this section alludes to four organizational general purpose technologies mentioned by Lipsey et al. (2005): 1) factory-based craft working and standardization (as from 1800), 2) mass production (as from 1910), 3) lean production (as from 1980), and 4) the internet (as from 1995).

The notion of rationalization is a common thread in this story. Through the replacement of human action with technology, rationalization means that efficiency, predictability, computability, and control come to be seen as dominant cultural values (Ritzer 1983). Rationalization can have many advantages, such as reduced waste of materials; higher labour productivity; better quality and lower costs of products; less dirty, dangerous or tedious work; and the creation of new, more interesting jobs. But there can also be disadvantages as well, such as the direct loss of jobs or the 'stripping' of jobs, and the undermining of the status and skills of workers. This section also considers to what extent the rationalization of production, labour, and consumption in the first machine age differs from or matches rationalization in the current second machine age.

Figure 2 Overview of organisational characteristics during the first and second machine age



Second machine age
RATIONALIZATION OF COGNITIVE LABOUR

From 1980

Computer enables automation of services

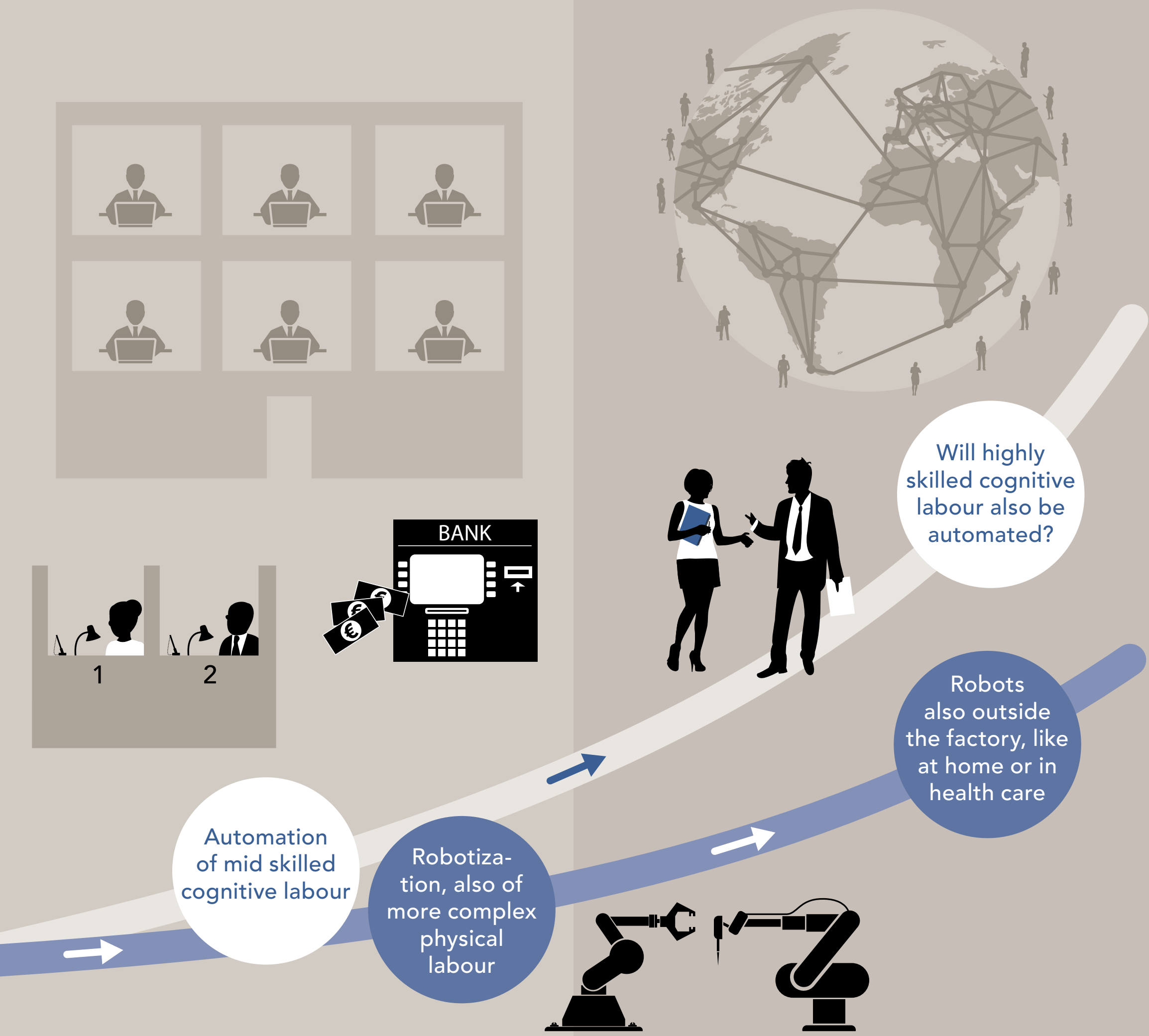
Digitization of physical and cognitive labour: integration of digital and human labour

Digital Taylorism

From 1995

Internet boosts internationalization and platformization of labour

Digitization value chains: 'The world as one big efficient (smart) machine'



Optimization of global production chains through regional outsourcing and offshoring of unskilled labour to lower income countries.

Optimization of global value chains through offshoring of un-, medium and high skilled labour, reshoring highly automated production, and on-demand crowd sourcing of cognitive labour.

Looking back historically, we can perceive a constant quest to organize production, labour, and consumption ever more efficiently. Over history, we can see that thinking about rationalization has changed radically four times in response to new organizational general purpose technologies. This section describes these four transformations (see Table 2 and Figure 2).

Table 2 Overview of four organizational general purpose technologies that have influenced the organization of production, labour, and consumption.

Age/types of machines (cf. Brynjolfsson & McAfee 2014)	Time period	Organizational general purpose technologies (cf. Lipsey et al. 2005)
First machine age: machines that provide muscle power	As from 1800	Factory-based working and craft production of luxury goods
	As from 1910	Mass production and consumption
Second machine age: machines that provide thinking power	As from 1980	Lean production and mass
	As from 1995	Digital internet economy

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Factory-based working and craft production of luxury goods

At the end of the nineteenth century, people had to be wealthy to afford a car. At that time, there were a handful of manufacturers with wealthy customers who could have a car built to order for them. The work was organized roughly as follows (Subirana et al. 2006). The workplaces involved in making a car of this kind were staffed by highly skilled workers. These workers usually started as apprentices and developed into all-round skilled workers able to perform a wide range of tasks. The standardization of specific parts of the work made it possible to farm out these tasks to machine shops in the region equipped with generic machine tools that were capable of performing all kinds of operations. These manufacturers made fewer than a thousand cars each year, and rarely were more than fifty identical cars made.

Right now, there are still operators engaged in small-scale car production. The Dutch family firm Donkervoort Automobielen, for example, makes customized sports cars without electronic aids (Gollin 2011). IT only helps in operational management, the design of car models, and global marketing.

Mass production and mass consumption

At the beginning of the twentieth century, production and consumption were scrutinized in a completely new way. Henry Ford was one of the people behind this new approach, and the associated socioeconomic paradigm is often dubbed

Fordism. The crux of this approach is a symbiotic relationship between mass production and mass consumption: to allow mass consumption, products should be affordable and workers should earn enough. This condition formed the basis for a culture of consumerism: no longer was status conferred merely by the skill of making something, but it was also conferred by being able to buy something. Ford wanted to make a car that was affordable for workers, required little maintenance, and was easy to operate. He therefore sought a method of production that was more efficient than the existing craft production process.

He found this in the use of the moving conveyor belt, which enabled a standard car to be put together piece by piece in a systematically well-considered way. Breaking the production process down into simple subactivities meant that low-skilled workers sufficed for most tasks. This radical simplification and specialization of the work made it possible to mechanize and later robotize certain parts of production in the second half of the twentieth century.

Engineers not only mechanized subprocesses but also aimed to redesign the factory as 'a big efficient machine'. Frederick Taylor (1856-1915) was one of these mechanical engineers and, based on his work (1911), a scientific vision of this form of business management arose, known as 'scientific management' or Taylorism. A stopwatch was used to measure the performance of workers in order to boost productivity[17]. In the craft production process, the knowledge needed to carry out production was for the most part in the craftsperson's head. Taylorism meant that it is principally the manager who has knowledge of the organization of the production process. In this way, some of the craftsperson's tacit knowledge, which is hard to transfer, makes way for the more explicit, codified knowledge of the manager. The hierarchical, bureaucratic management structure, with a clear separation between physical work and knowledge work, became a characteristic of this approach.

At the beginning of the twentieth century, American manufacturers embraced Taylorism to increase productivity but also to reduce the power of the trade unions (Montgomery 1979, p. 27). During the first half of the twentieth century, Fordism and Taylorism also came to be widely accepted in other Western countries, including the Netherlands (Lintsen 2015). years, this body of ideas has undergone continuous renewal. For example, IT provides scope for not only mechanizing simple subactivities but also automating or robotizing them. According to Ritzer (1983, p. 105), robotization is the ultimate way of rationalizing social practices and minimizing dependence on people. In highly automated industries, such as the food industry, the vision of a fully autonomous factory, a 'megarobot', will soon become reality (FME et al. 2014, p. 19). A

17 In response to scientific management, questions also arose about the impact on job quality and task impoverishment. The effects of rationalization and automation on job quality therefore form part of an ongoing debate.

megarobot such as this would bring the ideal of the factory as a big efficient machine into reality. In the Netherlands, Philips' highly automated shaver factory in the town of Drachten is regarded as an example of how reshoring of manufacturing is achievable via smart manufacturing, and that production does not by definition have to take place in low-wage countries.

Lean production and mass personalization

For most industrial practices, ever closer cooperation between digital and human labour is a more obvious solution than full automation (WEF 2015, p. 17). This approach is known as lean production. As in Taylorism, the pursuit of cost reduction and greater efficiency is of key importance here.

Encouraged by the post-war scarcity of materials in Japan, Toyota developed lean production in the 1950s. According to Womack et al. (1990, p. 13), this approach combines the advantages of craft work and mass production because it avoids the high costs of the former and the rigidity of the latter. In lean management, the customer's wishes and the avoidance of waste are of prime importance (Deming 1986). There are four core principles: teamwork, communication, efficient use of raw materials and talents, and continuous improvement (*kaizen*). Engineers, programmers, and workers collaborate in self-managing teams. This blurs the classic Taylorist dividing lines between mental and physical tasks, and between research, product design, and the production process. The factory floor becomes a kind of laboratory in which the production process and product undergo constant refinement.

Spurred by the economic crisis and the emergence of IT, lean management broke through in the USA and Europe in the early 1980s. Digitization of the production process yielded a host of opportunities for closely tracking the production process. Examples include Manufacturing Resources Planning (MRP), for monitoring the use of materials, and Statistical Process Control (SPC). This kind of information can be used to improve products and the production process, for example to prevent wastage of materials. Japanese companies have traditionally been used to giving their workers access to such information (Kagono et al. 1985, pp. 112-113). Such a company is, as it were, an open source community in which teams of workers themselves can seek the ideal interaction between digital and human labour (cf. WEF 2015, p.7).

The use of lean management in the West coincided with the growing globalization of the economy in the 1980s and 1990s. It was no longer merely a question of optimizing production chains within the factory, but of optimizing global production chains. This enabled the further subdivision of production tasks, further specialization and the relocation of production. Regional outsourcing came to be supplemented by global offshoring: the relocation of a plant, and thus labour, to a low-wage country. This initially affected low-skilled physical labour with little added value. Closer attention was paid to the customer's wishes: whereas the Model T Ford was supplied in a single model and a single colour (black), you can now, for instance, order hundreds of different types of BMW Minis. This is because the BMW Mini is made in the factory only after being ordered by the customer. This is a case of just-in-time production and mass customization, which is made possible by flexible computer-controlled production processes.

In the 1980s, the services sector also came within the grip of lean management and associated thinking on industrial efficiency. IT played a driving role in this. The services sector in the USA accounted for at least 88% of the 1,000 billion dollars that the business community invested in IT in that decade (Rifkin 1995, p. 91). Particularly the banking sector – banking is a major information management process – expected a considerable impact from the automation of all kinds of tasks, such as the management of bank accounts and transfers. Managers wanted to use IT to rationalize the business process and also gain more control over personnel (Edwards 1994). The management of the UK banking sector wanted, for example, an industrial production model instead of the existing artisanal master-apprentice system. In the 1980s, the hoped-for productivity growth nevertheless failed to materialize. This phenomenon has become known as the productivity paradox, or the Solow paradox, after the economist and Nobel Prize winner Robert Solow (1987) (discussed further in Chapter 4).

Since the beginning of the 1980s, Taylorism has therefore also influenced the services sector. Brown et al. (2008; 2011) refer to 'digital Taylorism'. In a similar way to manufacturing at the beginning of the twentieth century, this time the 'artisanal' services sector is being reconsidered and, where possible, split into simple subtasks, which can be easily outsourced, offshored, or automated. Automation is thus spreading from simple physical work (robotization) to knowledge-based work done by medium-skilled and high-skilled personnel (Frey & Osborne 2013).

The digital internet economy[18]

Since the beginning of this century, many new digital tools have arisen not only for tracking the production process within the factory more closely but also for gaining an understanding of consumer behaviour and the way in which products are used outside the factory gate. Optimization therefore no longer focuses purely on production chains but on the entire value chain (see also Figure 3 for an overview of the differences between the period as from 1980 and as from 1995, and Table 3 for an overview as from 1800). The use of, for example, RFID,

18 The term 'digital economy' was first used by Tapscott (1995).

Figure 3 Overview of organizational characteristics of the second machine age

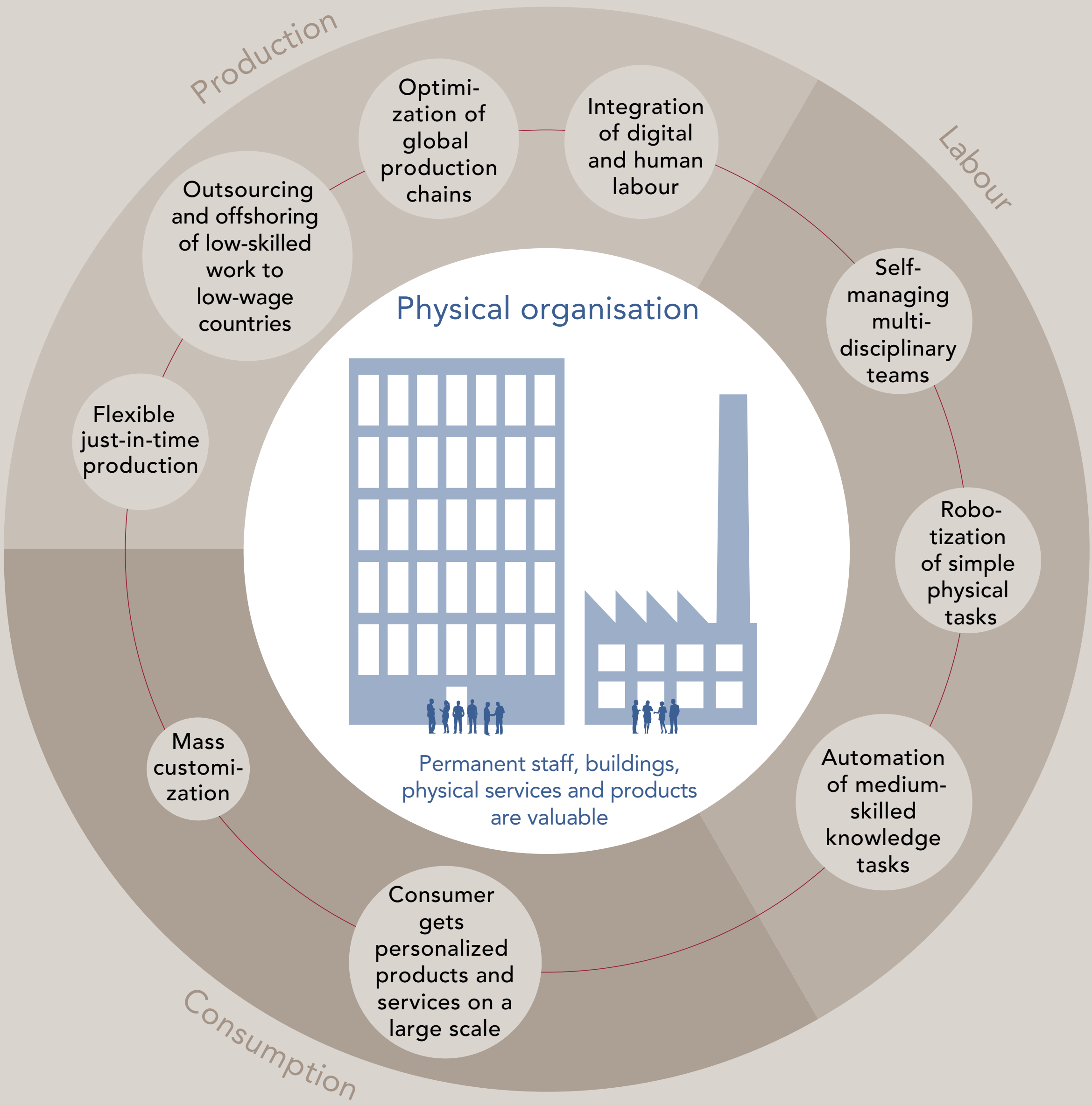
SECOND MACHINE AGE

RATIONALIZATION OF COGNITIVE WORK

As from **1980**

Lean production and mass personalization

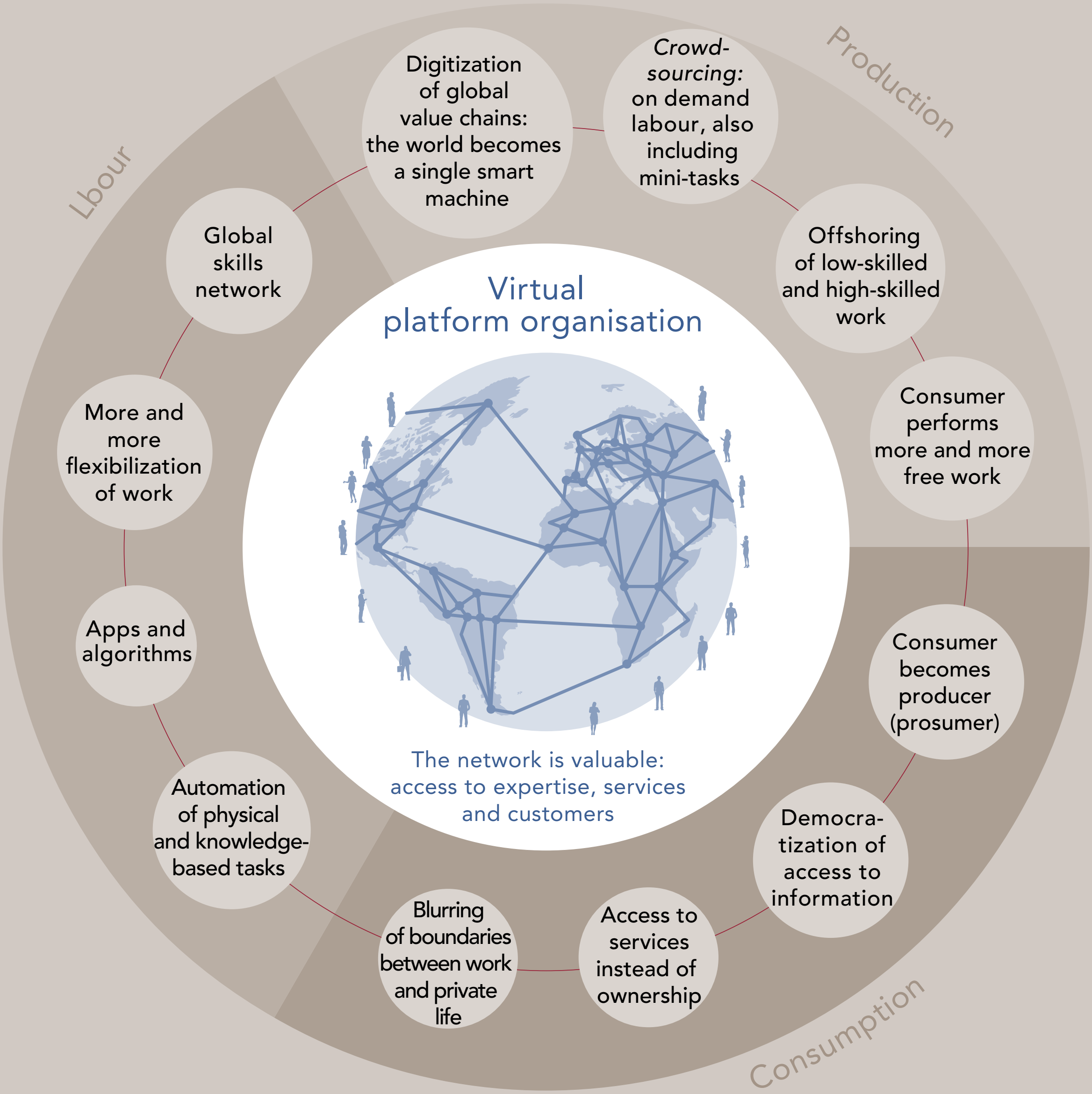
Rationalization of cognitive processes in industry, Service sector, and creative sector



As from 1995

The digital internet economy

Rationalization of global value chains via high precision management approach to production and consumption



GPS and video cameras is leading to an evolution from lean management to 'high-resolution management' (Subirana et al. 2006, p. 11), or precision management. More and more data are becoming available on all parts of the value chain, allowing even more efficient organization of value-chain processes. In particular, highly digitized environments – Floridi (2014) refers to ICT-friendly environments – allow precision management based on the analysis of large streams of data (big data). A digital environment of this kind may be a factory or a warehouse. The French journalist Malet (2013) describes how, when he was a temporary Amazon employee, his employer monitored him every second via his scanner using Wi-Fi.

The behaviour of internet giants, such as Google and Facebook, which, via the internet, gain a real-time understanding of consumer behaviour, is an example of precision management. With the aid of click behaviour, Google profiles users, generates customized advertisements, directly measures the impact of these advertisements, and, based on this, bills its advertising customers accordingly. These capabilities for tracking products and people in the physical world are also expanding rapidly outside the factory. Examples include retailers who track their customers using Wi-Fi tracking. Via the Internet of Things, precision management may, in the view of Fleisch et al. (2014), soon be deployed throughout the physical world. Owing to its huge reach, one of the great promises of the Internet of Things is to prevent waste and inefficiencies at a system level, or the level of product streams, pools of machinery, energy networks, and transport fleets, sometimes even globally (Evans & Annunziata 2012, p. 5).

Since the mid-1990s, the advent of the World Wide Web has further bolstered the process of globalization and transformed relationships both between businesses and other businesses and between businesses and their employees and customers. Cairncross (1997) summarizes this in the popular phrase 'the death of distance'. The internet makes it possible to share work globally more easily than before. Not only low-skilled production work is being offshored, but so too are administrative operations and high-skilled tasks with high added value, such as programming, product design, and R&D. According to Brown et al. (2008), a global skills network is developing in which low-wage countries are providing both low-skilled and high-skilled people. Brown et al. therefore consider that Great Britain may become a high-skilled but low-paid economy. IT thus has a bearing on the business location policy of companies and therefore on the place where work takes place. Via IT, this enables companies to organize their product design processes around the clock and around the world: at the end of the day, teams in Europe pass on the baton to their colleagues in America, who pass it on in turn to their colleagues in Asia.

Far-reaching automation is now giving the business community scope for reshoring: the withdrawal of production from low-wage countries to the

West.[19] The decision to reshore also depends on many other factors, such as wage costs, transport costs, and coordination costs. Thus, for example, wage costs in low-wage countries such as China have risen sharply over the last decade (WRR 2013). In combination with an international call for better working conditions – for example, at the Foxconn factories that make Apple products (Hulst 2013) – this is encouraging robotization in countries like China and also the relocation of production to new low-wage countries. However, this is also creating a context in which reshoring is an option.

The internet is changing the relationship between employers and employees. The use of flexible work, in the form of zero-hours contracts, on-call workers, temporary contracts, temporary workers, and self-employed people, has been increasing for years. Between 2007 and 2014, this 'flexible layer' in the Netherlands grew from around 20% to 25%, and it is expected to account for 25% of the economy in 2020 (Ploeg & Vermeend 2014; see also Chapter 6). The mobile internet has, for example, substantially cut the costs of finding and hiring freelance workers, and the number of freelancers who are available on call via apps has risen sharply (Noort 2015). Internet platforms that match supply and demand are facilitating the emergence of this on-demand economy. Uber is one of the best-known internet platforms (or internet agents) and brings together taxi customers with permanent taxi drivers, as well as with private individuals who are on call in their 'leisure time'.[20]

The advocates of the on-demand economy see leisure time as a huge reservoir of untapped thinking power – Shirky (2011) talks about a 'cognitive surplus' – that companies and people can monetize in all kinds of ways (Ismail et al. 2014, p. 67). Opponents see the economization of leisure time as a threat. Reich (2015) is afraid of a Mechanical Turk economy,[21] in which people do the stultifying minitasks left after most work has been automated, for a few pennies and at random times (Manjoo 2015). The internet and mobile telephony have already blurred the boundary between work and private life. If existing firms

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19 There are companies, such as VDL Groep, that have chosen on principle to keep their production in the Netherlands by using high-technology tools. Faith in IT, coupled with the rapid decline of European industry, has sparked a policy debate about the reindustrialization of Europe. The European Commission advocates a European Industrial Renaissance (http://europa.eu/rapid/press-release_IP-14-42_en.htm) and aims to raise industry's share of the European economy from around 15% in 2014 to 20% in 2020. According to Heymann & Vetter (2013, p. 4), however, this objective is extremely ambitious.

20 UberPop has been banned in the Netherlands. UberPop enables anyone to register for work as a taxi driver with his or her own car. The Human Environment Transport Inspectorate (ILT) has decided that this is not authorized because drivers are not licenced commercial drivers, and so this is an illegal taxi service.

21 The term Mechanical Turk refers to Amazon's internet platform on which people perform a task that requires human judgement and that cannot yet be performed by computer, in exchange for a small fee. This entails such tasks as labelling photographs to make them more easily searchable, classifying objects on satellite images, checking address details of restaurants, etc.

adopt the Mechanical Turk platform model, the on-demand economy will blur that boundary even further. In Germany, considerable public agitation arose in 2012 when an IBM plan became known to turn 8,000 permanent employees into freelance workers who could then sign up for specific assignments via a 'crowdsourcing' platform (Oertel & Wagner 2013). Caldwell (2009) sees the crowdsourcing of work as the new outsourcing.

The internet has also altered the relationship between companies and customers. The internet is making new business models possible and thereby offers new answers to questions such as: Who is the customer? What does the customer value? How can the customer be helped for a suitable price? (Magretta 2002) At a time that IT makes it possible to deploy a better business model in the market, this may lead to disruptive innovation. The importance of the internet in generating new business models has been growing steadily since the 1990s, and the most disruptive models come from the digital industry. Fleisch et al. (2014) show how various phases in the development of the internet lead to new types of business models. During the first phase of the internet – web 1.0 between 1995 and 2000 – companies began to see the internet as part of their infrastructure. New digital practices emerged, such as e-commerce, open source, digitization, and the internet as a way of gaining a better understanding of customers, and giving away free products (Freemium) to allow the sale of added products (Premium), to collect relevant data, or sell advertising. In about 2005, a few web 2.0-based business models emerged in which users were of central importance. Numerous niche markets became profitable as a result of the internet phenomenon of the 'long tail' for products that are not on the shelves, but for which there are customers (Anderson 2006). Small local bands were, for instance, able to upload their music to iTunes, which meant that not only the 'big artists' are on sale there; online marketplaces also made it possible for small brands to offer their products. Companies used social media to ask users to design products themselves (user design), generate ideas and content (crowdsourcing, for example YouTube), or bring in money (crowdfunding). The expectation is that the scope of the Internet of Things – remote operation of devices, monitoring of the environment, generation of data – will again feed new business models. Because the Internet of Things generates a lot of data that provide an understanding of people's risk behaviour, internet entrepreneur O'Reilly expects, for example, that insurance will become an important business model of the Internet of Things (Morozov 2014).

The existence of affordable, powerful innovative technology – such as smartphones, digital cameras, commercial drones, labs-on-a-chip, computers, the internet, 3D printers – offers users a host of opportunities for making, organizing, and sharing things themselves (Anderson 2012). We are seeing the emergence of the Do-It-Yourself (DIY) economy. Anderson (2006, p. 73) draws the following conclusion in his book: "When the tools of production are available to everyone, everyone becomes a producer." The consumer has thus increasingly become a producer. Users are also doing all kinds of things jointly, as in Wikipedia, the Open Source Initiative, or the sharing of music, films, or tools with one another via peer-to-peer networks. This is referred to as the advent of the sharing economy. This becomes possible first of all because making and sharing an extra digital product is virtually free, and secondly because the internet makes the coordination of sharing inexpensive and easy. Certainly owing to the advent of the Internet of Things, Rifkin (2014) sees a bright future for cooperation between various public communities (collaborative commons). According to Rifkin, the Internet of Things will make it possible for people to produce energy themselves on a large scale and share this with one another. In this way, the Internet of Things will put an end to the current economic system dominated by large multinational companies.

Other authors tend to see these phenomena leading to 'platform capitalism'.[22] Companies such as Apple, Google, Facebook, Airbnb, and Uber are turning existing markets on their heads through their method of innovation. Digital platforms enable them quickly to enter new markets, integrate products and services, get other parties to help innovate, and involve users in innovation (Kreijveld et al. 2014). In the terminology of Ismail et al. (2014), these are exponential organizations, a form of organization which, in the authors' view, is an optimum fit for the current internet economy. The characteristics of such organizations include the following: they are based on an informational world view and are made possible by the internet; they want to transform the existing market radically (in other words, be disruptive); they have as few permanent personnel as possible and as many personnel on call as possible; they form a community that can be used via crowdsourcing (optimization of free labour (Terranova 2012); they automate as much as possible (Ismail et al. (2014, p. 71) state that in the age of the Internet of Things, algorithms will determine the success of companies). They also make the least possible use of their own capital goods and ensure good access free of charge to the goods of others (cf. Rifkin 2000). These characteristics may, separately or in combination, ensure extremely efficient business management. In 2014 Ismail et al. (2014, p. 51) compared, for example, the exponential organization Airbnb with the lean management organization Hyatt Hotels. Airbnb had been in existence for six years, employed 1,324 people, and made use of the bedrooms and free labour of 500,000 people in 33,000 towns; as a result, it needed virtually no property assets and yet had a stock market value of ten billion dollars. That was more than the value of Hyatt Hotels, which then had 45,000 employees and 549 hotels. The Airbnb model is also much simpler and cheaper to scale up than Hyatt's.

22 In response to the debate about the taxi service Uber, the term *Plattform Kapitalismus* was coined in the German public debate (Lobo 2014).

Table 3 Organization of production, labour and consumption during the first and second machine ages.

Age	First machine age		Second machine age	
Generic organi-zational technology	Factory-based and craft production of luxury goods (as from 1800)	Mass production and consumption (as from 1910)	Lean production and mass personalisation (as from 1980)	Digital internet economy (as from 1995)
Object of rationali-zation	Product	Physical production process	Knowledge process in manufacturing, services and creative sector	Global value chains (production and consumption)
Organisation of production	Factory as a workplace in which crafspeople work with generic machines	Mechanization of physical work: 'factory as a big efficient machine'	Digitization of physical and knowledge work: integration of digital and human work	Digitization of value chains (production and consumption)
	Standardization allows coopera-tion in regional networks of workplaces (regional outsourcing)	Optimization of mass production within factory	Optimization of global production chains via regional outsourcing and offshoring of low-skilled labour to low-wage countries, flexible just-in-time production	Optimization of global value chains via offshoring of low-skilled and high-skilled work, reshoring of highly automated production, crowdsourcing of (free and paid) work
Organisation of labour	Craftsmanship and standardization	Mechanical Taylorisme	Lean management / Digital Taylorism	High resolution management: approach to production & consumption
	Tacit knowledge of craftsman	Scientific management via stopwatch	Including MRP, statistical process control	Internet of Things: big data, artificial intelligence, sensors
	Master-aprentice: transfer of craft knowledge	Distinction between knowledge work (high, medium) and physical work (simplification and mechanization)	Self-managing multidisciplinary teams with access to information	Digital networks and platforms, algorithms & apps (e-coaching), democratization of access to informa-tion
Organisation of consump-tion	Luxury products tailored for rich customers; majority makes its own clothing, food, et cetera.	Affordable mass products and mass consumer	Mass personalization / mass cutomization	Consumer becomes producer (pro-sumer). Access to services instead of ownership of goods. Blurring of boundary between work & private life (economization of 'leisure time') and production and consumption

This new business model brings us back to the quote by Goodwin (2014) at the beginning of this chapter and explains why it is in the current internet age that these developments can take place. Part of the success of the companies cited is that they can occupy a strategic position between the buyer and seller with their platforms (Kreijveld et al. 2014, p. 44). Via iTunes, for example, Apple has placed itself between artists and record companies, on the one hand, and the consumer, on the other. Successful platforms can in this way come to be dominant and even over-dominant. Where the internet allows direct contact and cooperation between users and other users (collaborative economy; see Botsman & Rogers 2010), and between users and service providers without the need of intermediaries, the emerging digital platforms conversely occupy a strong middleman position between makers and users.

Such 'platform capitalism' can lead to a winner-takes-all economy in two allied ways. Because successful platforms become more and more interesting to users as a result of network effects, the risk of market monopolization can firstly arise swiftly (Kreijveld et al. 2014).

A second risk is that a small group of the superrich rake in the profits made using the unpaid or low-paid labour of many. *The Economist* (2015) calls the current internet generation of high-tech billionaires from Silicon Valley "silicon sultans" and compares them with the "robber barons", as critics scornfully dubbed the fabulously wealthy and powerful employers of the first machine age.

2.3 Conclusion

This chapter has described a number of characteristic trends of the IT revolution and explored what this has meant for the organization of production, labour, and consumption. This final section describes the main developments that the IT revolution enables and how they accordingly shape rationalization in this second machine age. The IT revolution gives hands and feet to the informational world view that is becoming dominant in more and more practices, and permits the current emergence of the Internet of (Robotic) Things. IT is allowing a shift from mechanical Taylorism to digital Taylorism. Where mechanical Taylorism mainly concerns physical work and its mechanization and automation, digital Taylorism enables automation to spread to cognitive labour, including in the services sector. Besides automation, digital Taylorism is also leading to the internationalization and flexibilization of labour. Recently, we have seen the emergence of global virtual and liquid internet platforms for crowdsourcing both paid and unpaid labour. Finally, IT offers users a host of opportunities to become producers themselves, but imperceptibly they are in many cases also becoming free employees of companies.

Breakthrough of informational world view and emergence of the robot internet

An informational world view drives the IT revolution. As part of this process, all kinds of mechanical, cognitive, and organizational processes are defined in terms of digital information streams. Such an informational world view may have disruptive consequences. This vision was formulated in the 1950s, but assumed ever greater practical significance in the 1980s (Boogaard et al. 2008). For example, digitization transformed the entire value chain for photography. As a result of the rapid and continual development of IT, many IT-based products follow an exponential development process in terms of price (ever cheaper), size (ever smaller), and numbers of users (ever more). In this context, IT is getting involved with existing technologies and processes, via the convergence of digitization and production processes (mechatronics/robotics), and information and communication processes (ICT).

According to many thinkers, companies, and governments, we are now on the eve of a far-reaching convergence between the internet and the physical world. This is referred to as the Internet of Things. Because the internet is thereby acquiring senses (sensors) and hands and feet (actuators), we can also talk about the Internet of Robotic Things. Besides people, the internet is increasingly connecting objects, services, and industrial processes to one another. The Internet of Things is expected to allow the digitization of value chains, including global ones, which means that the focus of services on smart products is steadily growing in importance (Lanz & Maurer 2015). The 'traditional' physical separation between low-grade manufacturing in low-wage countries and high-grade innovation in Western countries is fading. One of the questions for the future is therefore where the smart factory – as the primary place where innovation on production processes and products takes place – will end up.

From mechanical to digital Taylorism

It is in interaction with social processes that the IT revolution assumes its transformative power. This is why this chapter described how IT allows new ways of organizing production, labour, and consumption. It is rationalization, or a search for more efficiency and more control, that mainly drives the continuous search for new organizational approaches. To gain an understanding of this development, this chapter compared the first and second machine ages.

At the beginning of the last century, a scientific vision of operational management came into being. Rationalization in the first machine age thus concerned the standardization of elements of products and the physical manufacturing process in the factory. Based on this mechanical Taylorism, the artisanal factory had to be radically redesigned as 'a big efficient machine'. By splitting work processes into simple tasks, it became possible to use low-skilled workers, mechanize some tasks, and later automate or robotize them. Robotization is thus preceded and enabled by a radical reorganization of the labour process.[23]

In the 1980s, the advent of IT also brought the services sector within the grip of industrial efficiency thinking. Digital Taylorism is also cited because, in a similar way to manufacturing, the 'artisanal' services sector is being reshaped and, where possible, split into simple subtasks that can be automated. In the second machine age, rationalization therefore also focuses on the cognitive labour processes in the manufacturing, services, and creative sector and, after the advent of the internet, increasingly on global value chains, i.e. on not only production but also consumption. This steady expansion is made possible by 'scientification' and the use of increasingly accurate measurement methods. The internet and increasingly the Internet of Things allow the close, often real-time, monitoring of production, logistical, and consumption processes. This is opening up a new area of further rationalization of production and consumption, and potential automation of work.

Internationalization, automation, and flexibilization of work

The standardization of products makes it possible to outsource work. This happened in the first machine age, mainly in regional networks. Production chains are still usually regionally concentrated, but since the 1980s the IT revolution has also allowed the international outsourcing of work. In the 1980s, this chiefly entailed the offshoring of low-skilled physical work to low-wage countries inside and outside Europe. The higher the degree of automation of certain processes, the less dependent they become on human labour and wage costs. In this way, the reshoring of highly automated production is becoming one of the options for companies. Reshoring is also becoming an option because wages in countries like China are rising. Robotization has consequently become a global phenomenon. Automation no longer applies only to simple physical tasks, but also increasingly to more complex physical and knowledge-based tasks. The advent of the internet means that a global skills network is developing that also allows the global outsourcing of medium- and high-skilled knowledge-based work. This is bringing together the advent of flexibilization and the platformization of labour. The virtual and liquid platform organization is casting aside the concept of a business as a physical place where permanent employees come together. It is now a question of optimizing on-demand access, via crowdsourcing, to paid and unpaid work.

Consumer as producer and free employee

From the user's perspective, things have now turned full circle in a very interesting way. At the beginning of the last century, consumption, notably of

23 The study by Frey & Osborne (2013) shows what human tasks computers or robots can take over, but disregards the organization or reorganization of the labour process that usually precedes it.

luxury goods, was chiefly something for rich customers. The masses made the majority of products, such as food and clothing, themselves. Methods of mass production have created mass products, but have also allowed mass consumption and its associated culture. Mass customization made it possible for the masses to acquire mass products in a customized way. IT is now offering users the chance to make all kinds of products and services themselves and share their use with others. As outlined above, companies are also making use of this by getting the consumer to perform as many tasks as possible. This entails unpaid work and self-service enabled by IT. As a result, the boundary between labour and private life and between production and consumption is, as at the beginning of the twentieth century, becoming blurred again.

Intermezzo

Interview with
Jan Luiten van Zanden,
Utrecht University

Intermezzo

"The short-term memory of society is limited"

It is not easy to demonstrate a connection between technology and employment. A multitude of macroeconomic factors affect employment in the Netherlands, a country which responds particularly strongly to fluctuations in the business cycle, explains the Professor of Economic and Social History at Utrecht University.

"If you look at the simple economic facts – the evolution of unemployment and economic growth – the one thing that really strikes you is the fact that when the world economy is faring well, the Netherlands does well, and that when the world economy is faring badly, the Netherlands gets an extra-hard whack." That the Netherlands in the 1990s performed so 'amazingly well', was, according to Van Zanden, partly due to various imbalances that are currently being eliminated. "That's why the Netherlands was hit harder in the past crisis years than most of its neighbouring countries," claims the 2003 winner of the Spinoza Prize. Van Zanden received this highest distinction in Dutch science partly for his research on the economic history of the Netherlands. The Netherlands benefits extremely well from the good years, but in the bad years the country is hit extra hard when the blows come raining down. This is also evident in the evolution of unemployment, asserts Van Zanden. However, this pattern, which may be linked to our small open economy, says more about the general macroeconomic development of the Netherlands than about technology, he acknowledges.

In any event, it is best not to interpret fluctuations in the business cycle as structural problems. Van Zanden refers to the great concern, in around 2006, about the growing tightness of the labour market. Many feared that population ageing would lead to a completely overstretched labour market. That threat has now vanished completely. "The short-term memory of society is limited."

The doomsday scenario regarding the consequences of robotization – robots will take over more and more tasks from humans, sharply cutting employment – likewise does not resonate with Van Zanden. History does not provide any parallels for such a dramatic, negative scenario. In the past, new technologies have not caused high unemployment. In the 1930s, for example, the cyclical downturn lay at the root of the unemployment. And the structural unemployment in the 1970s and 1980s arose partly from the large-scale deindustrialization and the rigid and stiff way in which labour market bodies responded. Nevertheless, Van Zanden, who also immerses himself in the history of social inequality, can certainly see worrying developments. He refers to the United

States, where the underclass only has access to low-paid jobs and cannot benefit effectively from growth in prosperity. This development is not technology-driven, but related to the institutions on the labour market, education, and training. In the Netherlands, too, he can see a shift towards 'precarization': "many people feel that the quality of their labour is being reduced and that they are ending up in worse working conditions. Going from a permanent job to a temporary one, for example."

Although it seems as if the internet is boosting competition, the problem is not there, according to this scholar of economic history. Although the internet makes the 'supercommercialization' of labour possible, what matters is how this is handled. Van Zanden advocates policy to combat negative spirals on the labour market; in his view, technology has little to do with this. "The players involved should target an effective labour market policy, a policy that, among other things, leads to a good education system suited to the labour market."

In another area, technology can, in his view, play a major part: in getting economic growth, and sustainable growth at that, going in Europe. Entrepreneurs can see the potential of this, but uncertainty about things like consumer confidence, investment in companies, and the macroeconomic context are inhibiting their ambitions and thus a possible wave of growth. The way in which the economy is organized, the labour market institutions, education, technological potential … all these are important, but not determining factors.

Van Zanden alludes to the current sustainability debate, driven by technological and economic dynamics, and normative aspects. He draws a parallel with the development of the welfare state, which came about to combat the excesses of industrial capitalism. "A normatively driven development, not because it was technologically necessary, but because society wanted it."

3 Technology and employment in a historical perspective

Jan Korsten with the assistance of Harry Lintsen and Johan Schot

The industrial capitalist society took shape as from the mid-eighteenth century. A number of technical innovations and developments in the economic, political, and social spheres set a radical modernization process in train. The driving force was the emergence and development of a series of new generic technologies which each brought about a new industrial revolution. Thus, steam engines, cast iron, and railways in the nineteenth century drove the first industrial revolution. From the end of the nineteenth century, steel, electricity, and the internal combustion engine drove the second industrial revolution, while information and communication technologies since the Second World War shaped the third industrial revolution (see Annex 2 for an explanation of the classification of the period into three revolutions).

This chapter describes how technological innovation in the Netherlands proceeded on the basis of these three technological revolutions: the introduction of steam (section 3.1), electricity (section 3.2), and IT (section 3.3). The questions to be answered in this context are as follows: To what extent did new technologies from the beginning of the nineteenth century bring about a transformation of Dutch society and the Dutch economy? What factors and players brought about such a breakthrough? Did the Netherlands have its own patterns and its own set of periods? Was the development gradual or did it proceed in sudden leaps forward? What consequences did new technologies have for (the organization of) labour? What role did the government play in this?

This chapter is based on scientific research conducted in the Netherlands in the past 25 years on long-term changes in technology and society in the nineteenth and twentieth centuries. This research affords insights into the course and pace of innovation processes in the Netherlands, the impact of the 'sociotechnical landscape'[24] on the development of such innovation, and the 'technical regime' that brings together technology, rules, knowledge, and

24 The entire body of social and technical facilities.

players (Schot et al. 1998, p. 28; Lintsen 2005, pp. 18-20)[25]. Annex 3 provides a historical overview of the development of the working population and labour productivity from 1800 to 1965.

3.1 Enabling policy for the first industrial revolution

In the Netherlands, the industrial revolution and the breakthrough of steam technology did not get going until the second half of the nineteenth century, much later than in Great Britain, for instance. Nevertheless, historians do not describe the Netherlands as having 'lagged behind' on this. The Netherlands merely did things differently. The country had specific factors and circumstances that gave the industrialization process a character of its own. In the first decades of the nineteenth century, for example, the business community showed limited willingness to invest. Business had yet to recover from the adverse effects of the French oppression and wars on the European mainland. Entrepreneurs were concentrating mainly on survival and less on the application of the new technologies then already being employed in Britain.Insufficient provision of capital also prevented external funding. This was because at the beginning of the nineteenth century the banking system in the Netherlands was not yet well developed, and the capital market functioned far from optimally. Entrepreneurs who needed capital for investment were in most cases therefore reliant on informal networks, including family networks. Without these networks, it was difficult to get the required funds together. In addition, prospects on the various markets for new products were uncertain. Protectionist measures imposed by other countries put international sales opportunities under pressure, and a strong domestic market was not available. The Netherlands was in practice not yet a single unit, with towns and regions operating relatively autonomously and using, for example, their own units of measure. Transport infrastructure was also organized regionally (Lintsen 2005; Zanden & Riel 2000, pp. 194-203).

According to Lintsen (2005), in the first half of the nineteenth century the Netherlands was trapped in its own technical and economic order. Its economy was based on wind power and the associated technology. However, windmills were unable to bring about industrialization with its larger-scale production, a role that was nevertheless reserved for watermills in Great Britain at the beginning of the industrial revolution. Another trap was the central role that agriculture played in the Dutch economy. The Netherlands had a highly specialized agricultural sector, from which it drew its strength. Agriculture was not, however, the sector in which the new technologies were important (Lintsen 2005, p. 127; Zanden & Riel 2000, pp. 237-256).

25 Scientific research in the past 25 years resulted in two series of surveys, the six-part series *Geschiedenis van de Techniek in Nederland*. De wording van een moderne samenleving 1800-1890 (Walburg Pers Zutphen 1992-1995), and the seven-part series *Techniek in Nederland in de twintigste eeuw* (Walburg Pers Zutphen 1998-2003).

Under the leadership of King William I – who in Great Britain had acquainted himself with steam technology and the emergence of modern industry – the Dutch-Belgian Kingdom had since 1815 begun creating fertile ground for industrialization. Modern transport infrastructure – crucial for the supply and removal of products and raw materials – was developed, a knowledge infrastructure was built up, colonial trade was reorganized via the *Nederlandse Handel Maatschappij* (Netherlands Trading Society), and sectors important for industrialization – mining, the iron industry, and mechanical engineering – were fostered.

As from 1815, the Kingdom worked on new transport and infrastructure. In collaboration with market players, the government began rolling out a national network of surfaced roads, canals, and railways. The accessibility of the seaports of Amsterdam and Rotterdam was also an important priority in this regard. Where possible, the State made a financial contribution, although this was not always possible owing to the high national debt (in part another legacy of the Napoleonic Wars). Work took place everywhere; in 1823, for example, work started on the construction of the Zwolle-Meppel-Groningen/Leeuwarden road, the first road in the north of the Netherlands. One year later, the North Holland Canal opened, giving the port of Amsterdam a much better link with the sea via Den Helder. In the south of the country, the Zuid-Willemsvaart canal was dug between 's-Hertogenbosch and Maastricht. Dutch shipyards also acquired experience in the construction of steam-powered inland waterway vessels. By 1828, 28 such vessels had already been built. On 1 June 1836 William I gave his assent to the construction of the Amsterdam-Haarlem railway. A limited company, the *Hollandsche IJzeren Spoorweg Maatschappij* (Holland Iron Railway Company), financed the construction. On 20 September 1839, the first train travelled from Amsterdam to Haarlem (Filarski & Mom 2008).

Knowledge infrastructure had by now also blossomed. The first engineering courses had been launched from the beginning of the nineteenth century. In 1842, for example, an engineering course was introduced at the *Koninklijke Academie van Burgerlijke Ingenieurs* (Royal Academy of Civil Engineers), a forerunner of Delft University of Technology. Five years later, the Royal Netherlands Society of Engineers allowed the exchange of knowledge and experience (see, for example, Lintsen 2005, p. 127).

The political developments of the 1830s (which ultimately resulted in Belgian secession in 1839) and the running out of control of the State finances delayed the industrial revolution in the Netherlands. It was not until the reform programme, which was launched under the direction of J.R. Thorbecke in 1848, that the basis was laid for a strong, stable liberal State that created favourable conditions for further economic development and growth. The reform programme also led to a reorganization of the public finances. Coupled with the improving economy and world trade, this gradually helped give entrepreneurs a favourable wind, making them more willing to invest in new technologies that could increase their production (Lintsen 2005, pp.124-126).

Breakthrough of steam technology as from 1850

Steam technology finally broke through in the Netherlands as from 1850 (see Table 4). This application became accessible to more entrepreneurs, including in remote parts of the country. The newly built infrastructure not only enabled entrepreneurs to supply the required coal more cheaply but also made it easier for them to serve new markets at home and abroad. The latter was important because as a rule investments in steam-powered machinery only yielded a return at higher production levels. Switching from steam slowly became an increasingly obvious choice. As steam technology became more dominant, new or revamped equipment came onto the market that could not be used in combination with, for example, wind power. This new equipment boosted the spread of steam technology (see for example Lintsen 2005, pp. 135-136).

The use of steam engines in the weaving mills of the textile industry in the Dutch town of Twente provides a good idea of developments. In the 1850s, the first steam-powered looms were introduced into the Twente textile industry. In 1852, the company G. & H. Salomonson opened in Nijverdal the first steam-powered loom built according to the English model. In 1854, the steam engine was powering more than 400 looms there. By 1860, 2,000 steam-powered looms were in use in Twente, in the ten steam-powered weaving mills. At that time, there were also still around 8,500 manual looms in use; in other words, by no means all textile firms were switching to steam. The inadequate infrastructure in Twente meant that the location of companies dictated whether switching to steam was commercially viable. In 1853, for example, 10 tonnes of English coal cost 90 guilders in Almelo. For operators in Enschede, the added cost of transportation from Almelo and Enschede was around 32 guilders per 10 tonnes, a cost increase of more than a third. Given the large quantities of coal needed (the output of steam engines was still far from optimal), a switch was therefore not initially viable for textile firms in Enschede, and it was more profitable to invest in modern manual looms with fast shuttles. In the following years, the improved infrastructure and the advent of more efficient steam engines made it economic for all Twente textile firms to switch to steam as well as expand. In 1900, Twente had 36 steam-powered weaving mills housing a total of 20,000 power looms. These textile firms provided work for more than 17,000 workers, nearly twice the number of workers in 1851 (9,375 workers) (Fischer 1983, pp. 65-90).

Table 4 Number of power units in industry in the Netherlands, and size of the working and general populations over the period 1850-1890.

	1850	1860	1880	1890
Steam engine	290	820	2,740	3,930
Gasmotors			10	20
Windmills	3,050	3,400	3,120	1,790
Horse mills	1,930	1.710	910	570
Watermills	470	500	250	160
Total	5,740	6,430	7,030	6,470
Working population in industry (x 1,000)	300	326		482
Population of the Netherlands (x 1,000)	3,100	3,300		4,000

Source: Lintsen 1995, p. 192.

Smaller firms as driver of industrialization in the Netherlands

Unlike Great Britain, for example, the wave of industrialization that swept the Netherlands in the second half of the nineteenth century did not bring about the advent of large factories, a development that would not materialize until after 1890. Until then, small firms – firms with fewer than ten workers – remained dominant. In 1860, 80% of the working population worked in small businesses, with the corresponding figure for 1889 being 77%.

Production by small companies nevertheless changed radically over that period in terms of its nature and methods. This was primarily because these companies switched on a massive scale to steam power and the associated machines. However, small businesses remained in which the owner often carried on working on site. The small business thus formed the driving force behind the breakthrough of steam in the Netherlands. Forges, small shipyards, and building companies purchased modern iron tools that were powered by a steam engine or traction engine (Lintsen 2005, pp. 142-143; p.159).

Secondly, mechanization of parts of the production process led to production companies, such as those in the textile industry, becoming organized differently. In the textile factories, a central steam engine powered looms and other machinery. The textile factories were subdivided into departments that each carried out an operation of their own. Production was concentrated into factory buildings, which meant that home weavers quickly disappeared (Lintsen 2005, pp. 157-167).

3.2 The second industrial revolution: breakthrough of electricity as a new generic technology

The period 1890-1920 was a transitional one for energy technology; during this time, the steam engine faced competition from alternative power sources in the form of gas-fired engines, internal combustion engines, and electric motors, which were smaller, more flexible, and simpler to install. Competition arose between various systems, with the electricity system ultimately becoming dominant. In the Netherlands, this led to the breakthrough of the large company and associated rationalization process.

A reliable and affordable electric motor had been undergoing development since the 1830s. However, the lack of a good electricity supply prevented large-scale use, and only larger firms could generate electricity themselves using their steam facilities. For example, the engine plant of Gebroeders Stork in Enschede had a DC facility for lighting and an electric travelling crane. When the company's Board had built a power plant of its own, the entire factory switched to electric power in 1901.

The economic climate at the end of the nineteenth century was sound: business conditions were buoyant for a long time, which meant that the industrialization process continued and there was scope for innovation. This became evident in, for instance, investments in the electricity system and the building of an electricity grid. Initially, municipal authorities, whether or not in cooperation with private operators, took the initiative of setting up a municipal power station. Regional power stations came later. The advent of steam turbines and the breakthrough of alternating current allowed further scaling-up and more profitable operation. .

To steer the growth of the electricity system in the right direction, the State and the provincial authorities assumed responsibility for its further development. Provincial electricity grids arose, managed by provincial electricity companies. Electrification of the Netherlands was completed by 1939, including in rural areas. The Netherlands thus led the way on this (Hesselmans and Verbong 2000, pp. 125-139; Hesselmans, Verbong & Buiter 2000, pp. 141-159).

Table 5 The electrification of the Netherlands 1913-1939.

Year	Electrified munici-palities	Total number of munici-palities	Number of power stations	Total capacity in MW	Total supplied to grid in millions of kWh
1913	180	1,121	82	98	110
1916	300	1,120	76	171	210
1919	405	1,118	111	239	320
1925	868	1,082			
1930	1,011	1,078	50	754	1,400
1935	1,056	1,060			
1936			46	1,339	1,800
1939	1,048	1,054	45	1,419	2,400

Source: Schot, Lintsen & Rip 2000, p. 157 (Table 3.3) and p. 159 (Table 3.4).

Because industrial links were attractive for the provincial electricity companies, the latter offered companies contracts at favourable prices. Even for larger businesses that still generated energy themselves, this made it appealing to switch to the public grid. Thus, in 1921, Philips concluded a contract with PNEM (Provincial North Brabant Electricity Company) for the supply of electricity.

The extent to which the electric motor would alter industry was also clear from the increase in installed capacity. In around 1850, Dutch industry had an installed capacity of 50,000 hp, which was principally based on wind power. Forty years later, this capacity was 80,000 hp, chiefly generated by steam power. By 1930, this capacity had, partly through the use of electric motors, already risen to 2 million hp. Growth then continued unabated from 4.5 million hp in 1950 to over 45 million hp in around 2000 (Hesselmans and Verbong 2000, pp. 125-139; Hesselmans, Verbong and Buiter 2000, pp. 141-159; Lintsen 2005, p.146).

Advent of rationalized factory

As from 1890, the second industrial revolution brought about the breakthrough of the large enterprise. In the Netherlands, too, relatively large enterprises arose relatively quickly (Zanden & Riel 2000, p.147). Whereas in 1889 medium and large enterprises accounted for 23% of industrial employment in the Netherlands, by 1913 the figure had risen to 76% (59% for enterprises with between 10 and 500 workers, and 17% for enterprises with more than 500 workers).

The efficient organization of production and close monitoring of flows of raw materials and semi-manufactured products were required to be able to meet the growing demand for products. In the 1920s, this prompted a new production regime, the rationalized factory geared to mass and series production.

Rationalization of production, labour, and organization went hand in hand with scaling-up in the economy and the advent of the rationalization movement, which yielded, for example, the management association NIVE and the development of organizational theories such as F.W. Taylor's scientific management (see also Chapter 2). The factory was regarded as a large machine where every detail needed investigation. New professional groups arose for resolving organizational problems, such as engineers, psychologists, and accountants. Following the example set by the United States, several very large enterprises arose in the Netherlands that integrated the entire production column as far as possible: Shell, Unilever, Philips, Staatsmijnen (the current DSM), AKU (the current AKZO), and Hoogovens. The smaller undertakings, which were still important in the Dutch context, looked to join forces in cooperative arrangements and cartels (Lintsen 2015, pp. 169-174).

A well-known example of rationalized mass production in the Netherlands was Philips. In 1926, Philips Natlab developed an affordable radio for the general public, a device that was also designed for large-scale production on a conveyor belt – one of the most conspicuous forms of the rationalized factory. In the Netherlands, the conveyor belt also came into use in serial production in smaller undertakings. In the 1930s, a conveyor belt was used by Heemaf, the Hengelo-based supplier of electrical machinery and appliances, in the production of telephones, by the machine manufacturer Stork in the production of motors, and by the footwear manufacturer Bata in the production of shoes (Lintsen 2005, pp.166-169).

The modernization of the economy was a period of great socio-political dynamism. A pillarized society arose, consisting of a well-organized civil society with trade unions, farming unions, and employer organizations. Issues such as the broadening of suffrage and – partly in response to social unrest – the improvement of the working and living conditions of workers made their way onto the political agenda. In 1887, a labour inquiry initiated by the House of Representatives of the Dutch Parliament uncovered all kinds of abuses in factories and workplaces: extremely long working hours, night work by children, unhygienic and unhealthy working conditions, low pay, and so on. To counter the excesses of industrialization, social legislation was therefore enacted, including Van Houten's Children's Act in 1874, the first Labour Act in 1889, and the Accidents and Illness Act in 1901 (Zanden & Riel 2000, pp. 311-341; Brugmans 1961, pp. 403-426).

3.3 The third industrial revolution casts a shadow

Process of social change

"Few realize that this greatest of all inventions since the steam engine heralds a completely new era for the world," claimed sociologist Fred L. Polak in an address he gave on being appointed Professor of Sociology at Erasmus

University Rotterdam in 1949 (Polak 1949, p. 8). Polak was alluding to the invention and development of the computer. In subsequent years, the feeling arose that the computer would usher in a new industrial revolution that would radically transform society and result in the elimination of much employment.

Data processing and computation

The 'digital calculating machine', as the computer was initially often called, was in fact the next step in the processing of administrative data. The scaling-up of industry and the growth of banks, insurers, and other service providers meant that the size and complexity of administrative systems had increased since the end of the nineteenth century. After the Second World War, this scaling-up continued unabated, in part due to the advent of the welfare state. Processing of the growing volume of data led to the continuous redesign and optimization of administrative processes and the use of mechanical, electromechanical, and electrical technologies, such as accounting machines, typewriters, and punched card equipment. In the end, the search for new aids accordingly resulted in the digital calculating machine.

The first mainframe computers were in locations where practice and science came together – for example, in the Mathematical Centre, at PTT, Shell, and Philips – and were used primarily for performing complicated calculations. In the Netherlands, Shell was one of the pioneers of computing. The company had a research group of its own for measuring and controlling Shell processes. As from 1959, a process computer controlled part of the Shell refinery at Pernis. In the 1950s, scientists and the business community teamed up on the development of new, widely usable computers. For example, insurers made capital available for this.

The high costs of purchase, management, and maintenance and a lack of qualified personnel prevented the rapid spread of computers. In 1959, 29 mainframe computers were operational in the Netherlands. Service centres came into being in the 1960s in response to the real need felt by small and medium-sized enterprises and institutions for administrative automation of payroll systems, invoicing, and premium calculation. One of these centres was the Centrale Elektronische Administratie (Central Electronic Administration, CEA), affiliated to the insurance company Centraal Beheer, which J. de Pous, the then Dutch Minister for Economic Affairs, opened on 21 April 1961. CEA developed standard programs for calculating the salaries of workers in the metal industry, sailors in shipping companies, and municipal government officials. The company also ran courses to teach the clients' administrative personnel about automated administration (Bogaard et al. 2008; Duffhues et al. 2011, pp. 176-177).

Training infrastructure

With the advent of the software sector, the business and scientific communities sought to professionalize training courses in informatics. The *Stichting Studie centrum Administratieve Automatisering* (Foundation Study Centre for Informatics) established in 1958 (renamed the *Stichting Nederlands Studiecentrum voor Informatica* [Foundation Dutch Study Centre for Informatics] in 1970) was one of the organizations that led the way on this. For example, in 1960 this organization set up a course for junior programmers, following this up four years later with the *Automatisering en Mechanisering van de Bestuurlijke Informatieverwerking* (Automation and Mechanization of Administrative Information Processing, AMBI) course. The *Nederlands Opleidingsinstituut voor Informatica* (Dutch Training Institute for Informatics) later arose from this. At the beginning of the 1970s, training courses came into being in higher vocational education, in the form of business informatics at 'heao' (higher economic and administrative education) colleges, and a higher informatics course at higher technical colleges. It was not until 1981 that the first informatics courses got off the ground at the universities (Bogaard et al. 2008, pp. 123-135).

At the beginning of the 1970s, the first steps were also taken to enable secondary school and pre-university students (known in the Netherlands as 'mavo', 'havo', and 'vwo' levels) to find out about informatics. One of the ways in which this took place was via the Elementary Computer Science course for secondary education students. In the 1980s, mainly after the advent of the personal computer (PC), the government and business community devised many more initiatives to familiarize the population with computer use. At the end of the 1980s, the government decided to opt for IBM-compatible MS/DOS computer systems as standard for educational purposes. Computers appeared in all schools in the Netherlands, and workers could purchase computers for home use via 'PC private projects' and thereby find out about a computer independently (Bogaard et al. 2008, pp.148-149, pp. 156-207).

Continued focus on industrialization

Developments in measurement and control technology after the Second World War created new opportunities for getting machines not only to perform mechanical operations but also to respond intelligently to changes in the production process. The exploitation of these opportunities was, however, not straightforward, and was in most cases unprofitable. The industry therefore continued building on existing production technologies (Lintsen 2005, pp. 177-182), and computers were not used for the time being. This applied also to textile production in the Tilburg region.

Economic growth in the Netherlands in the 1950s was spurred by international trade. The wages policy followed by the Dutch Government meant that wage costs were low for entrepreneurs. The latter invested heavily in expanding production, sparking growth in employment.

The various authorities actively encouraged the establishment of new industrial enterprises via an industrialization policy. For example, the municipal administrations of 's-Hertogenbosch and Tilburg set up investment companies enabling enterprises to rent or buy business premises on favourable terms. Municipalities also invested in the construction of industrial sites and modern residential areas. The aim was to create the best possible business climate, and mayors actively sought to attract new businesses (Korsten & Lintsen 2015).

Until the 1960s, signs of approaching problems, such as a decline in profits, were picked up only to a very limited extent. The Chair of the Tilburg Chamber of Commerce, for example, alluded repeatedly to the vulnerability of the economy in the Tilburg region. Dependence on the production of woollen fabrics caused anxieties about the future, and cooperation between businesses was needed to allow fresh investment and a better response to market fluctuations. In Tilburg, however, such cooperation failed to materialize. The abandonment of the wage cost policy at the beginning of the 1960s triggered wage cost rises that undermined firms' profitability and revealed problems below the surface. Weaker industries came under pressure, including the Tilburg textile companies. Calls for collaboration with the scientific community to make the industry fit to face the challenges of the future and find solutions, including technical ones, to its problems – such as rising wage costs – led nowhere. The municipal administration and Chamber of Commerce in Tilburg were also unable to change anything. Between 1959 and 1974, 64 of the 83 Tilburg textile factories closed their doors, with the remaining firms disappearing in the following years. Whereas 12,890 people were still working in the Tilburg textile industry in 1950, that figure had dropped to only 1,376 by 1980 (Korsten & Lintsen 2015).

Automation

Nevertheless, there were sectors in which the business community, the scientific community, and government cooperated in a united way on modernizing production technology through the use of computers. A clear example is the dairy industry, which wanted to reorganize the labour-intensive cheese dairies that were still virtually artisanal and transform them into large-scale plants that were as automated as possible and geared around an industrial process. From the mid-1950s, the sector pursued two aims with a joint research body, NIZO: to modernize and scale up existing machinery and to develop a completely new, virtually continuously automated, uniform cheese production process. In the early 1970s, this ultimately resulted in the Casomatic, which is still at the heart of modern cheese dairies (Berkers & Korsten 2013, pp. 36-60).[26]

26 In 2013 and 2014, Eric Berkers and Jan Korsten, on behalf of FrieslandCampina, researched the R&D history of FrieslandCampina and its predecessors. The development of industrial cheese production was one of the subjects covered.

In most production companies, the use of computer-regulated control systems was primarily intended to improve control of the production system and achieve better product quality (Vermij 2003, pp. 302-316). Automation often only became interesting on articles for mass consumption, such as bulbs, radios, and televisions. It entailed perfecting the rationalized factory through the introduction of self-monitoring and self-regulating machines and mechanized transport (Lintsen 2005, pp. 176-177).

In the 1970s, computers became smaller, more powerful, and cheaper. The microprocessor also provided a fresh scope for controlling machines without expensive central computer systems. More flexible automated production systems arose, such as production robots that enabled manufacturers to respond more effectively and more quickly to changes in market demand and fluctuations in sales. In 1982, more than fifty robots were operational in the Netherlands (Lintsen 2005, pp.177-182).

Influence of the crisis in the 1970s and 1980s

A period of economic growth that had started in around 1950 came to an end in 1973. The oil crisis, in which OPEC countries hiked the oil price, marked the visible turning point. Confidence in the economy waned, stock markets plummeted, inflation raged unabated, companies invested less, and world trade stagnated. The first global recession since the Second World War had arrived.

Until 1979, the consequences of the crisis in the Netherlands turned out better than expected. This was because consumption by private individuals kept on growing. The Keynesian economic stimulus policy pursued by the Dutch Cabinet under Den Uyl (1973-1977) helped in this. By, for example, raising benefits and wages, increasing government spending on social and cultural initiatives, and extending grants and cheap loans to businesses, the Cabinet tried to keep the Dutch economy going. "The extensive system of social provision ensured that the economic downturn was directly translated into a drastic fall in consumption demand. The other side of the coin was that the government deficit began growing and that, due in part to increased taxes and social insurance contributions, wage costs rose more sharply than in other countries. In the economic situation of the time, the policy pursued by the Den Uyl Cabinet may have been appropriate, but the structural problems were not resolved, quite the contrary in fact" (Zanden & Griffiths 1989, p. 258).

The extensive international money market meant that it was relatively cheap to secure external financing, for both private individuals and companies. Whereas one billion guilders of credit was provided for consumption credit in the Netherlands in 1970, that figure had already risen to 7.8 billion guilders eight years later. The business community also made greater use of external financing. The equity capital of stock market-listed limited companies as a percentage of the stock market total fell from 38% in 1973 to 32% in 1978. Companies focused on diversification to improve the stability of their business and become less reliant on a particular activity. Cheap external financing allowed large-scale start-ups of new activities and company takeovers. Conglomerates such as OGEM, RSV, KSH, and Heidemij came into being, consisting of all kinds of divisions that had little or nothing to do with one another.

The second oil crisis of 1979 ushered in a new recession. Unemployment rocketed, interest rates rose, and consumption and investment fell. Rising interest rates sparked a crisis on the housing market and triggered a wave of bankruptcies. Between 1980 and 1984, 27,000 companies went bankrupt in the Netherlands, with 150,000 people losing their jobs. A new issue was that the unemployment was in part structural in nature, with demand and supply on the labour market no longer being in balance. To overcome the crisis, the first Lubbers Cabinet (1982-1986) made deep cuts to public spending. Social benefits, public sector salaries, and the minimum wage were cut, and grant schemes for businesses were scaled back (Zanden & Griffiths 1989, pp. 255-274).

Role of the region

The role of regional players proved crucial in finding a solution and creating new employment, both to offset the jobs lost due to the crisis and to meet the growth of the working population. The development of the Tilburg region (Central Brabant) illustrates this. Partly due to the creation of a favourable business climate with good infrastructure, service companies and organizations started setting up in Tilburg as from the 1960s, and this broadened the economic base. The favourable conditions for setting up businesses in Tilburg also attracted new industrial employment. At the beginning of the 1970s, Tilburg was even a serious contender for a new Volkswagen plant that would provide employment for 6,000 people. In the end, Volkswagen decided not to go ahead with a new plant. As plastering over the wound, however, Van Doorne's Transmissie set up in Tilburg (Korsten & Lintsen 2015).

In the 1980s, each region developed its own approach to dealing with the problems and getting the regional economy back on its feet. For example, the Tilburg region focused on creating a favourable business climate for the tourism and recreational sectors. The Eindhoven region saw high-tech industry as the engine of future development, while 's-Hertogenbosch focused more on services. To a greater or lesser extent, technology and technical infrastructure played a part in these developments. Of course, new technologies, such as the micro-processor, were integrated. An important driver was, however, the regional networks of players – businesses, municipalities, and provincial governments – which focused on expanding the strong and distinguishing features of the region.

3.4 Conclusions

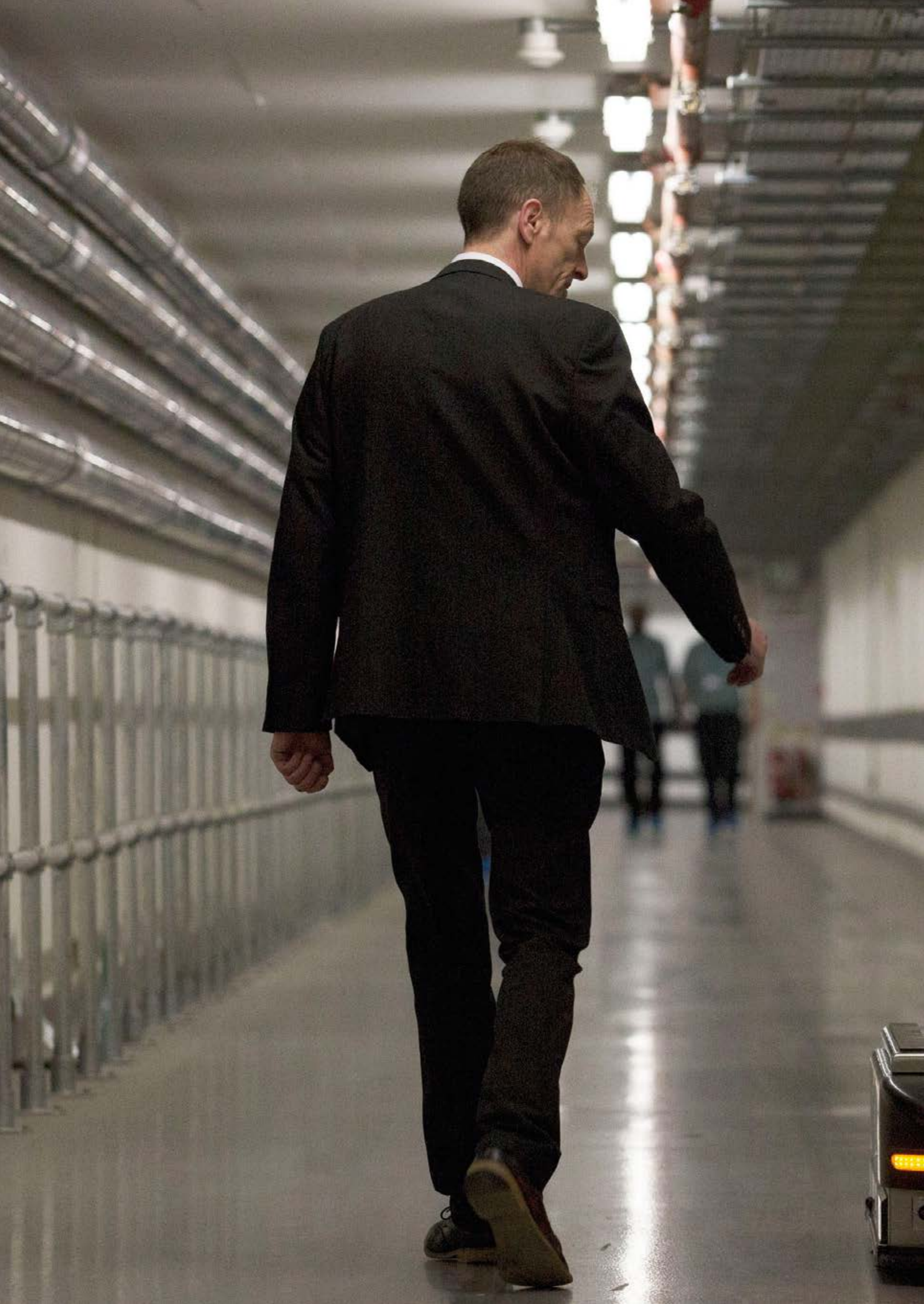
Over the last two centuries, new generic technologies – steam power, electricity, and information technology – have played a part in bringing about processes for change that led to social transformations. How great this role was depended on the broader economic, social, and political and administrative context. To make the best possible use of a new technology, society and technology needed to be well matched. A process of change and adaptation was needed for this in each case. In the case of steam and electricity, it took more than a century before the Netherlands was actually able to profit from this economically.

Government – in the form of municipal, provincial, and central authorities – fostered the implementation of new technologies by creating favourable conditions; in the nineteenth century via the creation of a transport and knowledge infrastructure, and at the beginning of the twentieth century via the regulation of new practices with the aid of laws and regulations, for example social legislation. However, this could only take place in cooperation with all the players concerned or their representatives.

The developments in the Netherlands proceeded very gradually and not suddenly. Various technologies carried on functioning in tandem. An important factor was the willingness of entrepreneurs to invest, with macroeconomic and financial circumstances playing a part. The government was able to perform a facilitating role by fostering a favourable business climate and thereby making investment attractive. The regions have increasingly played a major role in this.

New generic technologies provided fertile ground for the emergence of new organizational forms in business. During the first industrial revolution, artisanal work was mechanized and increasingly centralized in a single production location. The classical factory came into being. The second industrial revolution provided scope for the advent of large-scale rationalized factories and service providers. The third industrial revolution provided the technical capabilities for further control of the production process through the use of computers. How and at what pace changes took place depended to a great extent on the specific context.

In the Netherlands to date, new generic technologies have never brought about structural crises on the labour market. Macroeconomic and cyclical factors were always the most important cause of crises. The use of new technologies on the labour market has nevertheless always created a need to better harmonize the demand and supply of labour, for example through education.



2 Relationship between technology and employment

Intermezzo

Interview with
Bart van Ark,
University of Groningen
and The Conference Board (USA)

Intermezzo

"Embrace technology, and dare to experiment"

Bart van Ark, Professor of Economics at the University of Groningen and Chief Economist at The Conference Board, is convinced: "Europe and thus the Netherlands have a lot in their locker to enable technology adoption to be channelled in the right direction, but they certainly need to exploit these capabilities."

"Europe and the Netherlands must ensure that they do not lag behind in innovation and the adoption of new technology; that would be risky," warns Van Ark. "If we Europeans are not quick enough, we will become less competitive." According to Van Ark, every sector should therefore ask itself how it uses new technologies, even if these technologies are disruptive. This also applies to non-commercial sectors such as healthcare and education.

We are not doing too badly in the Netherlands, acknowledges Van Ark. The government's financial affairs are stronger, and at a macroeconomic level the recovery is perceptible. But in terms of scope for translating new technologies into innovation, products and services, there is still a great deal to be done. Van Ark stresses that what matters for achieving fresh innovation is no longer 'hard' ICT infrastructure, but instead new *applications* of existing technology. The take-up of new technologies in the Netherlands is also still slow. The degree to which this is merely typical of Dutch culture is, according to Van Ark, tricky to say. He is nevertheless clear that technology take-up is quicker in the USA than in Europe. This also has downsides, as shown by the link between rapid changes and labour market flexibility: "The risk is in people dropping out of the system and never coming back. That should be overcome by focusing closely on education and training, and in particular in getting businesses to play a major part in this so that they can retain good people."

Generally, the European economy, and the Dutch economy as part of this, differ in various ways from the American economy. Van Ark alludes to a lack of scale: the absence of a single European market. Particularly in services, the market is very fragmented. He explains that further integration of the European market is important (as with the European IP legislation and the Services Directive). Creating the right conditions for broad growth in Europe is very important for the Netherlands in particular. The current fragmentation impedes scaling-up of the input side: the introduction of technologies and innovation, as well as attracting capital and the 'best brains'. On the output side, Europe does not benefit enough from economies of scale or cheaper production and sales.

Van Ark therefore advocates completion of the liberalization of the internal market and the creation of frameworks within which national governments can operate: "Let the EU ensure that Member States do not get in each other's way. And then leave implementation to the Member States," advocates the professor. After all, national governments can really spur innovation, for example through educational policy with an emphasis on economic, innovative, and ICT skills, or a favourable business climate for investment in technology. Innovation can also be strengthened within the countries, he adds, citing successful regional innovative clusters such as Brainport. Van Ark goes on to say that at a regional level the concept of smart specialization offers opportunities, including for the Netherlands. In terms of implementation, the national government should leave a great deal to the regional or even urban authorities, with the associated resources. It is a question of getting scope for entrepreneurship, and cooperation between government, the business community, and the educational sector on innovation systems, to develop organically (in other words, not implementing a top-down industrial policy or foresight studies).

The message from Van Ark, the first non-American chief economist in the nearly 100-year history of The Conference Board, is to look at the policy experiments of other Member States and learn from them. Give people and businesses the opportunity to adapt. For example, design grants so that they help a business start up, but also so that that business can take off quickly. Fully throwing open the research market could also, in Van Ark's view, be fruitful. "We must not think in terms of 28 Member States, but in terms of a single European area, in which we can have various Silicon Valleys alongside one another." By providing scope for experimentation, as in the USA, innovation hubs attracting highly skilled people could arise in unexpected places. That would prevent European talent leaving for the USA.

Technology should therefore be embraced, and European institutions must facilitate this better. "Europe must use its institutions positively. And not break away!" He also pleads for the right incentives for organizations – which are largely lacking here, according to Van Ark. This requires cultural change. Thinking needs to go into policy, and such policy thinking must be coordinated at European, national, and regional levels. In this context, Van Ark advocates a stronger emphasis on regional regulation to facilitate decision-making.

4 Technology and labour productivity

Frans van der Zee

This chapter examines the relationship between technological innovation, productivity growth, and economic growth. What concepts and indicators are used to map this relationship, and what are their advantages and disadvantages? This question is central to section 4.1. Section 4.2 addresses the contribution that the IT revolution has made to productivity growth over the past ten to fifteen years. There is scientific consensus on the important role of IT in the growth figures in recent years, but scientists' forecasts for the impact of the IT revolution on economic and productivity growth for the coming years diverge sharply, as shown by section 4.3. And although productivity growth does not lend itself to policy intervention in a direct sense, section 4.4 rounds off the chapter with a number of important ideas for policy directions.

4.1 Labour market productivity growth in the Netherlands in perspective

Economic growth and productivity are two closely connected concepts. It seems logical to assume that the greater productivity is, the greater economic growth is. But the relationship for an economy as a whole is more complex. If we look at the economic growth of the Netherlands in past decades, much of it is attributable to the deployment of more people as a result of greater labour market participation, notably by women. Not only was there a sharp rise in the number of gainfully working people, but also the number of economically inactive people fell substantially. Whereas the ratio between economically inactive and active people[27] was 37 to 100 in 1980, this had fallen to 22 to 100 in 2010 (WRR 2014). Besides higher labour market participation, there was also an increase in productivity; in other words, an increase in production (output) from the same use of resources (input).

The most widely used gauge of productivity is labour productivity. Labour productivity can be measured in various ways. It is common to divide gross domestic product (GDP) by the number of hours worked, the number of workers, or the number of people (per capita). Looking at labour productivity in absolute terms, the Netherlands scores very highly internationally, coming

27 For a definition of 'active' and 'inactive' on the labour market as adopted by Statistics Netherlands, see http://www.cbs.nl/nl-NL/menu/methoden/begrippen/default.htm?ConceptID=336.

sixth in the world rankings in 2012, below only Norway, Luxembourg, Ireland, Belgium, and the United States (WRR 2014).

Although productivity in the Netherlands has risen every year in recent decades, two important observations should be made. Firstly, productivity *growth* in the Netherlands has tailed off sharply. CPB figures show that mean productivity growth on an annual basis was 3.4% in the 1970s, 2.0% in the 1980s, and 1.7% in the 1990s; this last percentage was also recorded in the subsequent period 2000-2009.

As Table 6 shows, growth in GDP per hour worked in the Netherlands has been dipping gradually as from the 1990s, falling to 1.5% on an annual basis. The crisis period shows a significant fall to a growth level of virtually zero, with an extremely laborious recovery to an average of 0.5% per annum in recent years. If we look at the evolution of labour productivity per capita, a more capricious pattern becomes evident; particularly the period as from the crisis is striking, with declining labour productivity. The current productivity figures are now somewhat better. The most recent analysis by CPB puts labour productivity growth (in working years) at 1.1% in 2015 and 1.3% in 2016 (see CBP 2015). Growth thus comes out as being lower than in 2014 (1.5%), but much higher than in 2013 (0.4%).

Table 6 Evolution of productivity in the Netherlands, mean growth per annum (in %).

Period	1970-1980	1980-1990	1990-2000	2001-2007	2007-2013	2009-2013
GDP per hour worked*	3.9	1.7	1.4	1.5	0.1	0.5
GDP per capita*	2.3	1.7	2.5	1.7	-0.6	-0.3

* At constant prices.

Source: OECD.[28]

A second observation is that the Netherlands has lost a great deal of ground on other countries. Whereas until 1980 the Netherlands was still an international leader on productivity growth, since 1980 it has been a good average performer among Western countries (WRR 2014). Over the period 2001-2007, before the crisis, annual productivity growth, in terms of GDP per hour worked, was much lower in the Netherlands than in Sweden, Finland, the United States, and the United Kingdom (all at or above 2%).

28 http://stats.oecd.org/Index.aspx?DataSetCode=PDB_GR

Table 7 compares the labour productivity growth of the Netherlands with that of Germany since the 1970s, and with that in the Eurozone and OECD countries as a whole since 2001. It is striking that over the period 2007-2012 the Netherlands appreciably lags behind Germany, the OECD, and the Eurozone as a whole. Since the 1980s, the Netherlands has not been doing as well as Germany, except during the period 2001-2007.

Table 7 Comparison of labour productivity growth* of the Netherlands, Germany, and the Eurozone (in %).

Period	1970-1980	1980-1985	1985-1990	1990-1995	1995-2001	2001-2007	2007-2012	2009-2012
Nehterlands	3.9	1.9	1.6	0.9	1.1	1.8	-0,3	0,4
Germany	3.8	2.2	2.5	2.5	1.3	1.6	0.3	1.4
Eurozone	..	..	..	..	..	1.3	0.5	1.3
OECD	..	..	..	..	..	2.0	-0.1	1.6

* Growth in real GDP per hour worked, mean annual growth.

.. : no figures available.

Source: OECD.[29]

Other factors influencing productivity and productivity growth

Although labour productivity is a widely used measure of productivity growth, a number of observations are in order. Labour productivity growth ostensibly means that the increase in productivity can be attributed to the labour factor. But appearances can be deceptive. Not only can the labour factor become more productive (smarter, better trained, faster), but so too can other production factors. For example, our computers and telephones become 'smarter'; raw materials are used better, employed with less pollution and recycled; and our machinery ('capital goods' in economics parlance) becomes increasingly efficient, flexible, and better networked (the Internet of Things, see also Chapter 2). Often the growth also lies in a smarter, more efficient combination of the production factors labour and capital. Furthermore, labour is increasingly replaced by new technology, in other words by robots, self-driving lorries and cars, and self-controlling production processes become driven by sensors and smart algorithms (smart industry or Industrie 4.0, see also Chapter 2). As technology replaces humans, 'labour productivity' is becoming increasingly meaningless as a concept.[30]

29 http://stats.oecd.org/Index.aspx?DataSetCode=PDB_GR

30 Suppose that a director and majority shareholder of a medium-sized enterprise completely replaces his staff with computers overnight, to keep one step ahead of the competition and cut his costs. This makes him extremely productive because all production can be attributed to him as the sole remaining worker in the business. But what does this explosive rise in labour productivity actually say?

A major flaw in the concept of labour productivity is that it does not reveal the underlying factors of productivity growth. If we only look at the number of hours worked, we do not know precisely how we have become more productive. This is because, in addition to the production factor labour, other factors also contribute to productivity growth, including capital goods and other inputs (raw materials, natural resources), as well as changes in technology. Thus, labour may become better educated and trained, and capital goods may, in response to technology and innovation, be replaced by a newer, more productive version (capital deepening).

In addition, there may be an improvement in general efficiency, in which labour, capital, and other inputs are combined, or greater total factor productivity (TFP), also known as multifactor productivity (MFP).[31] MFP notably covers disembodied technological change, or the impact of intangible assets (also known as intangibles) such as R&D, knowledge, and organization on production growth. There is also plausible statistical evidence that higher MFP and ICT use is closely interconnected (Bartelsman 2013; Corrado et al. 2007).

Splitting productivity growth into various components (better education, 'smarter' and thus more productive labour, or an improvement in the quality of the labour factor; smarter capital goods as a result of investment deepening, which is called capital deepening; and MFP growth) may, in the face of disappointing growth, provide a much better idea of where the problem lies or make it possible to identify the driver of success where there is noticeable growth. More targeted policy can also be formulated, where necessary.

4.2 The importance of technology, and in particular ICT, for productivity growth[32]

The growing importance of technology and innovation, and in particular ICT, in the economy and society, has strongly bolstered the attention given to measuring their contribution to productivity and productivity growth. The IT revolution, which has been going on since the 1960s, and which has taken on an even clearer form since the 1980s with the introduction of the PC and in the 1990s following the advent of the internet, is interesting, notably from the perspective of productivity.

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31 Productivity is output per unit of input. The input unit may consist of working hours (labour productivity) or of all production factors combined, including labour, machinery, energy, etc. (total factor productivity, TFP). In practice, TFP growth is measured as residual growth, in other words as that part of GDP growth that cannot be explained by the growth and composition of labour or capital.

32 Dit hoofdstuk spreekt over ICT (en niet over IT), omdat in de onderliggende economische data ook over ICT wordt gesproken.

It has been clear that ICT has brought about great changes in the production and work process. For a long time, however, it was unclear whether and where we could capture this investment in ICT in the productivity figures. This Solow paradox – named after a famous pronouncement by the American economist Robert Solow in 1987 (*"You can see the computer age everywhere but in the productivity statistics"*) – now seems to have been resolved, although fresh questions have recently been arising.[33]

Table 8 Breakdown of economic growth in market sector, 1996-2009 (percentage points).

	1996-2009	1996-2000	2001-2005	2006-2009
Growth of added value*	2.6	4.4	1.5	1.7
Contribution by determinants:				
Total capital and labour	1.6	3.2	0.1	1.3
Capital	0.8	1.6	0.4	0.5
Non-ICT capital	0.2	0.6	-0.1	0.1
ICT capital	0.6	1.0	0.5	0.4
Labour	0.7	1.6	-0.3	0.8
Multifactor productivity (MFP)	1.1	1.2	1.4	0.4

*Annual volume change, mean.

Source: Statistics Netherlands 2014a, based on CBS Groeirekeningen.

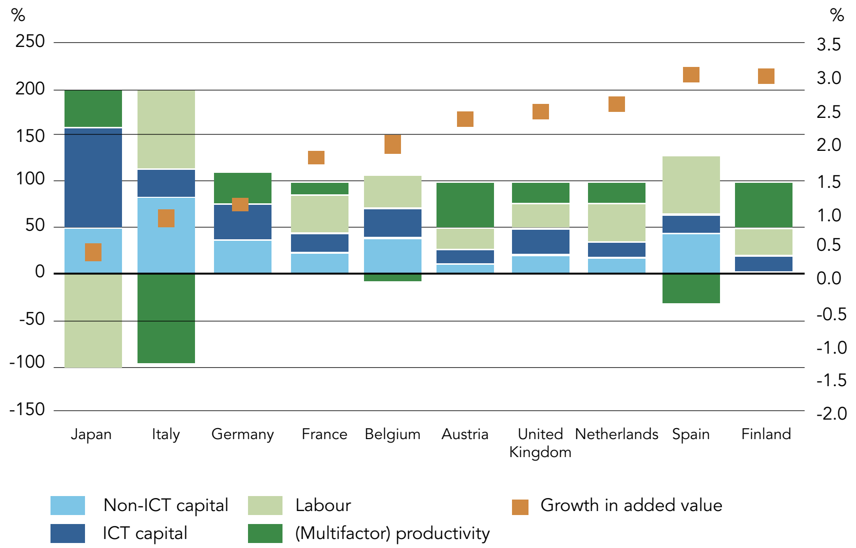
The contribution of ICT to economic growth can be measured in various ways.. For example, the stock of capital goods can be split into an 'ICT capital' element (computers and the like) and a 'non-ICT capital' element (buildings, machinery, cars, and the like), thus making it possible to determine their impact on growth. Another way of examining the contribution by ICT is based on the distinction between ICT-producing (such as chip manufacturer ASML) and ICT-using sectors (such as the banking sector and the travel industry).

Besides a productivity effect arising from ICT-producing sectors, ICT's contribution to productivity growth then consists of an investment effect by ICT-using sectors (capital deepening), and a general productivity effect as a result

33 In the scientific article 'The return of the Solow-paradox', Acemoglu et al. (2014) investigate the hypothesis of 'technology optimists' such as Brynjolffson & McAfee that IT will lead to great productivity increases that will rapidly render workers superfluous. They nevertheless find no clear evidence in the statistics for faster productivity growth, and, where they do find faster growth, there is, contrary to expectations, falling output and an even swifter fall in unemployment: "If IT is indeed increasing productivity and reducing costs, at the very least it should also increase output in IT intensive industries. As this does not appear to be the case, the current resolution of the Solow paradox does not appear to be what adherents of the technological-discontinuity view had in mind" (Acemoglu et al. 2014, p.1).

of improvements in efficiency due to ICT use.
If we look at the role and impact of ICT on the evolution of growth in recent years, it becomes clear that primarily ICT capital has played an important part and accounts for nearly a quarter of the growth (Statistics Netherlands – Centraal Bureau voor de Statistiek, CBS 2014a). With a small share of total production costs of around 5%, the contribution by ICT capital to economic growth is thus in fact disproportionally great. The contribution by the labour component is narrowly greater, by 0.7 of a percentage point. That the costs of ICT capital remain so limited is largely due to Moore's Law (see Box 2 in Chapter 2). According to this 'law', the number of transistors on a microchip doubles every two years, while production costs remain the same.

Figure 4 Breakdown of economic growth in market sectors 1996-2009, internationally (percentage points).



Source: CBS 2014a, based on EU KLEMS.

Figure 4 shows how the Netherlands fared over the period 1996-2009 as compared with other countries. It is striking that the MFP contribution in Italy and Spain is negative, versus a strongly positive MFP contribution in Finland, Austria, and Germany. MFP growth is especially smart growth in which intangibles such as R&D, knowledge, and organization are important factors. If we compare growth in Germany with that in the Netherlands, it is striking that the contributions by capital (ICT and non-ICT) and MPF are much greater than in the Netherlands[34]. The Netherlands catches the eye mainly due its large

34 It may also be pointed out that the Netherlands and Germany also have different sectoral structures.

contribution from the labour factor (see Table 9). ICT capital's share of growth is in absolute terms comparable to that in countries such as France and Austria, but is in the lower reaches. It is also striking that Japan compensates for the effects of an ageing population on growth (a highly negative labour component) through a very substantial contribution from ICT capital.

A second way of interpreting the relationship between ICT and productivity is to distinguish between ICT-producing and ICT-using sectors. Besides a productivity effect due to the ICT-producing sectors, the contribution by ICT to productivity growth then consists of an investment effect due to the ICT-using sectors (capital deepening), and a general productivity effect as a result of improvements in efficiency through ICT use. When this is applied to the Netherlands for the period 1996-2009 (see Table 9), what is most striking is the robust growth in ICT services, with growth of 10.8% (!) annually throughout the period, including a large share for MFP and ICT capital. Calculations by CBS show that the ICT sector, and in particular the telecommunications sector, makes a disproportionately greater growth contribution than would be expected from its size. The ICT-intensive sectors of commerce and finance also make substantial contributions.

Table 9 Breakdown of economic growth in market sectors by subsector, 1996-2009 (percentage points).

	Non-ICT sectors	**ICT industry**	**ICT services**	**Total**
Growth of added value*	2.3	-0.5	10.8	2.6
Contribution by determinants:				
Total capital and labour	1.4	-0.5	6.4	1.5
Capital	0.7	1.8	3.0	0.8
Non-ICT capital	0.2	1.3	0.9	0.2
ICT capital	0.6	0.5	2.1	0.6
Labour	0.6	-2.3	3.5	0.7
Multifactor productivity (MFP)	0.9	0.0	4.4	1.1
Sector size (% production costs of total)	94.8	0.8	4.4	100

Source: Statistics Netherlands 2014a, based on CBS Groeirekeningen
(* annual volume change, mean)

Besides the *direct* contribution by ICT, due to growth of the ICT sector and the contribution by ICT capital due to other sectors, there is also an *indirect* contribution by ICT to growth as a result of network effects and other 'externalities'. After all, the value of the use of ICT increases as more businesses employ it. This applies, for instance, to the steadily growing automation of production chains, in which the stock management of enterprises and customers is interconnected, enabling supplies to be automatically coordinated and also tracked in real time. The advent of the Internet of Things is making these network effects even more important. Moreover, the direct growth contribution by ICT disregards the question of how ICT can further strengthen the combination of production factors and facilitate innovation. However, it is very tricky to determine the scale of all these spill-over effects. The contribution by ICT and technology to productivity is therefore more general. In conclusion, we can state that the estimates of ICT's direct contribution to growth of productivity and the economy represent a lower limit. ICT's total computed contribution to growth is thus an underestimate. Furthermore, the underestimate of ICT to growth steadily increases because the nature of current investments is increasingly shifting to intangibles such as R&D, intellectual property, and more generally to knowledge and organization (Corrado & Hulten 2010). Partly for this reason, measuring the influence of intangibles is becoming steadily more important (Corrado et al. 2013).

4.3 The coming decades

After the years of the Great Recession that gripped the Netherlands as from 2008, the Dutch economy has been posting modest growth since 2013. In its recent March estimate, CPB forecasts GDP growth of 1.7% in 2015 and 1.8% in 2016. This estimate is subject to some uncertainty, concerning the pick-up in world trade, the oil price, growth in emerging countries including China, Brazil and Russia, but chiefly also concerning Europe itself.[35] What will growth be like in the coming years, what are expectations for the evolution of labour productivity, and what role will technology play in this?

A future of secular stagnation, robots taking our jobs, or excessive productivity growth?

In the longer term, technology and innovation play a not unimportant role in the current debate about economic growth prospects. But the heart of this debate among economists, which is mainly conducted by renowned and distinguished American economists, focuses on other factors and is thus not exclusively technology-oriented. In broad terms, two camps are discernible in this debate. One camp chiefly emphasizes supply factors that determine productive capacity (*potential output*, see also Annex 5), whereas the other camp focuses mainly, though not exclusively, on the demand side of the economy.

35 The threat of Greece's exit from the euro (Grexit), a depreciating euro, the effects of the ECB's QE (*Quantitative Easing*), which are still difficult to identify, and also progress on important aspects of further European integration, including the Single Market for Services (Services Directive).

Lawrence Summers figures prominently in this second camp. In 2013, he gave the 'growth debate' a fresh lease of life with his thesis that Europe and the United States risk ending up in a situation of long-term secular stagnation. Secular stagnation (*SecStag*) is a situation of low interest rates, low growth, and low inflation (or even deflation), linked to high unemployment (see for example Summers 2014 and 2014a; Teulings & Baldwin 2014; De Vries 2014).36 Future growth is principally low when viewed from the perspective of long-term potential growth, where savings exceed investment. Normally, the central bank – the ECB in the case of Europe – lowers interest rates, enabling both factors to come into equilibrium. But, in a weak economy with low inflation, the interest rate needed to achieve that equilibrium may become negative in real terms. In the words of Summers at the IMF Economic Forum held on 8 November 2013: "(…) We may well need, in the years ahead, to think about how we manage an economy in which the zero nominal interest rate is a chronic and systemic inhibitor of economic activity, holding our economies back below their potential." According to Summers, there are two ways of getting out of this *liquidity trap*: a good way and a bad way (*The Economist* 2015b). The bad way follows the path of a long period of very low interest rates, culminating in a new *bubble*, and thereby encouraging consumers to borrow and spend again. The 'good' way entails governments recognizing the problem and, through targeted policy, taking action by borrowing (thereby cutting the savings surplus) and also investing in a targeted manner. According to Summers, in a view also shared by the leading American economist Paul Krugman, the chances that Europe is facing a future of long-term secular stagnation are high, and greater than in the United States (Krugman 2014). This does not mean that technology and innovation are unimportant, but that the investment to ensure that new technology and innovation are actually harnessed and become part of production capital does not come about. Summers (2014b) also cites the effect of declining population growth and potentially technological growth itself both also bringing about reduced demand for new capital goods.

The other camp focuses mainly on structural supply factors that determine the potential growth path. Besides technology and innovation, these include various other *drivers*, such as demographics and population ageing, the impact of globalization, the influence of education and training, and also the consequences of income inequality on economic growth.

It is beyond the scope of this chapter to provide a detailed overview of all the various exponents and their arguments. Instead, this chapter adopts a more eclectic approach, shedding further light on several controversial exponents,

36 The idea of secular stagnation goes back to Alvin Hansen (1939): *"This is the essence of secular stagnation – sick recoveries which die in their infancy and depressions which feed on themselves and leave a hard and seemingly immovable core of unemployment."*

including Robert Gordon (2012; 2014), Ben Miller & Robert Atkinson (2013), Erik Brynjolfsson & Andrew McAfee (2011; 2014), and Jeremy Rifkin (1995; 2014). In all these contributions, technology is more of a focus than in the thesis of secular stagnation, although the impact of technology is also evident in that thesis, notably in (dwindling) demand for capital goods.

The differences between Gordon, Miller & Atkinson, on the one hand, and Brynjolfsson & McAfee and Rifkin, on the other, are stark. The latter group, dubbed by some as technology optimists, foresees great changes in how our economy is organized and achieves its potential. The former group, by contrast, emphasizes the importance of other factors that largely negate the net effect of technological growth, without denying the importance of technology and innovation. The gulf between both stances, in terms of the implications of technological change for growth, is remarkably wide. Whereas Rifkin talks about a future of *extreme productivity*, Gordon assumes productivity growth of 1.8% on an annual basis. But Gordon also identifies a number of powerful opposing forces which mean that economic growth in the long term works out at only 0.2% per annum, which would bring us back to a growth rate we last experienced in the nineteenth century. Gordon's growth rate expectation matches the expectations of Summers and Krugman for secular growth, although the underlying mechanism is significantly different. Gordon's arguments have therefore come to be known as supply-driven secular stagnation. To provide a clearer understanding of the various arguments, the following subsections outline the core of recent thinking on the part of Gordon, Brynjolfsson & McAfee, Miller & Atkinson, and Rifkin, and then briefly summarize their findings.

Gordon: Innovation versus six headwinds

In a provocative study with the revealing title *Is US Economic Growth Over? Faltering Innovation Confronts the Six Headwinds*, Gordon (2012) focuses on future potential output growth for the next twenty to fifty years, from 2007 onwards, and purged of crisis effects predating 2012.[37] He looks far back in time, from the beginning of the industrial revolution to the present day, and puts forward a number of interesting points of view. In Gordon's opinion, the computer and internet revolution that began in around 1960 reached its zenith in the late 1990s (the dot.com era), and its impact on productivity has largely ebbed away since 2004. The innovations that have taken place since 2000 have, according to Gordon, focused on entertainment and communication devices, which, though smaller and 'smarter', do not fundamentally change our labour productivity or standard of living, unlike electric light or the automobile. Gordon's central thesis is that innovation in the future does not offer the same

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37 Gordon (2014) sets out the same arguments, now in the light of supply-driven secular stagnation. Two headwinds do not reappear in this later version: globalization, and energy and the environment.

growth potential as in the past. Even if we assumed posited real per-capita GDP growth of 1.8% per annum, in other words an optimistic growth scenario with the same growth rate as in the two decades before 2007, eventual growth will turn out to be much lower.

Gordon sees six important structural *headwinds*: 1) growth being lower than in any period since the end of the nineteenth century; consumption growth per capita will, for the lowest 99% of the income distribution, be even lower still owing to demographic developments (population ageing and stagnant population growth, and the end of the baby-boomer generation's 'demographic dividend'); 2) increasing income inequality, with consequences chiefly for the middle class; 3) the effects of globalization and the internet, which have massively boosted outsourcing and offshoring worldwide; 4) the population's general level of education, which is no longer rising, but is even falling relative to other countries (an effect chiefly occurring in the United States, linked to rising costs of education and moderate school performance); 5) energy and the environment, and the measures needed to offset the impact of global warming; 6) the consequences of the debt burdens of governments and consumers. Each of these headwinds shaves a few tenths of a percentage point off growth, which means that, of the starting growth of 1.8%, growth of no more than 0.2% on an annual basis is left. Gordon sees primarily the combined effect of globalization and modern technology as being most daunting for the American economy. The parallels and similarities of Gordon's argument for the EU are clear and point in the same direction, although it should be noted that the long-term growth rate on which Gordon bases his argument is lower for Europe than 1.8%.

Brynjolfsson & McAfee: race with or against the machine?
Virtually diametrically opposed to Gordon are Brynjolfsson & McAfee (2011; 2014) of the MIT Sloan School of Management. In two influential books and other publications, Brynjolfsson & McAfee describe a world in which machines increasingly replace humans ("race against the machine"), with the pace of automation and digitization being so great that neither organizations nor the development of our skills can actually keep up. Massive replacement of labour takes place, and there is a "great decoupling" in which labour productivity rises further, but employment and (median) household incomes show a downward trend. According to Brynjolfsson & McAfee, three types of winners are discernible in this new world: 1) the high-skilled (versus the low-skilled and medium-skilled, who lose out); 2) capital (versus labour), and 3) the superstars (versus the rest).

According to the authors, this great decoupling is not a 'doomsday scenario'. The great decoupling reveals the growing pains of the new machine age, which entails the production of ideas more than physical production. This new machine age is also unique in that it is measurable (big data), is open to new, unimagined combinations, and proceeds exponentially (in other words, shows unbelievably fast growth).[38] In the words of Brynjolfsson & McAfee, we are reaching "the second half of the chess board", where exponential advances in computing power are translated into drastic changes. This means that we must not try to delay technological developments; rather, "(…) we need to race with the machine."

Apart from the speed and power of the development that Brynjolfsson & McAfee discuss, a number of other factors also come into play. For example, automation and digitization mean that the concept of scarcity assumes a different meaning from before. Digital goods are, after all, non-competing in use ('everyone benefits'), while their value can also rise further as a result of others also using/familiarizing themselves with them ('network externalities'). We are therefore in a fundamentally different market situation from Adam Smith's market of perfect competition and constant returns to scale. The old and trusted trope of the invisible hand ensuring arbitrage and market equilibrium is losing its power. ICT can massively transform market structures. The combination of the non-competing nature of digital goods and network externalities underpins 'winner-takes-all' markets. In such markets, enterprises make investments with a chance of profiting from the market and generating high returns. Where labour is paid on the basis of marginal returns, capital receives a premium in the form of *quasi-rents*[39] (Bartelsman 2010; 2013). This effect manifests itself principally in sectors that invest heavily in ICT. These sectors have something else in common: production can be scaled up substantially at relatively low cost, sometimes even at negligible marginal cost. Other emerging technologies, such as nanotechnology and biotechnology, are growing steadily in importance and underpin great potential productivity growth in services, as for example in healthcare (Bartelsman 2013; Byrne et al. 2013; Brynjolfsson & McAfee 2014). In the EU, policy measures further support these generic technologies (in EU policy parlance also dubbed 'key enabling technologies' (KETs)[40]). New materials (for example, ceramics, synthetic resins, graphene, and so on) offer great economic potential, while we can still expect a great deal from ICT, in the form of, say, big data and the opportunities provided by data analytics (Mokyr 2014). The same applies to opportunities offered by the Internet of Things and, more specifically, smart industry or Industrie 4.0 (see also Chapter 2).

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38 See also http://blog.ted.com/race-with-the-machines-erik-brynjolfsson-at-ted2013/

39 Quasi-rents are extra returns (rewards) for the production factor offered (as for example in the granting of patents).

40 In Europe, the term *key enabling technologies* is used in this context, referring to: microelectronics and nanoelectronics, advanced materials, industrial biotechnology, photonics, nanotechnology, and advanced manufacturing systems, see for example http://europa.eu/rapid/press-release_IP-12-685_nl.htm.

Rifkin: zero marginal cost society

Whereas Brynjolfsson & McAfee focus mainly on the *economics* of automation and robotization of the new generation of technologies and, besides all the opportunities, also paint a worrying picture of increasing unemployment and inequality, Rifkin (2014) chiefly stresses the positive aspects of these new technologies. According to Rifkin, we are at the beginning of an unprecedented technology revolution in which productivity may rise sharply. We are on the threshold of a period of extreme productivity made possible because the marginal costs of information, energy, and many physical goods and services are falling virtually to zero, thereby becoming freely and abundantly available, and thus no longer form part of market exchange. Propelling this zero marginal cost society are a number of technological developments that are taking place in parallel, reinforcing one another, and converging. Thus, the current internet is, coupled with a fast-digitizing energy network and a digitized logistics and transport network (self-driving cars), becoming a super Internet of Things platform. Rifkin's vision of the future encompasses not only the Internet of Things and ever smarter, sensor-equipped associated devices but also renewable energy and energy storage, hydrogen, robotics, and 3D printing.
Rifkin's vision brings him close to the camp of the futurists or 'technology utopians', whose main exponents are Ray Kurzweil and Peter Diamandis (founder of the Singularity University). Kurzweil (2005) foresees, as the ultimate consequence of Moore's Law, exponential productivity growth. Diamandis & Kotler (2012; 2015) argue that we are entering an era in which the speed of innovations, in computing, healthcare, 3D printing, robotics, and artificial intelligence, will increase exponentially, bringing a future of global abundance within reach within a generation. Rifkin, Kurzweil and Diamandis represent an interesting, but nevertheless clear minority in terms of expectations for productivity growth.

Miller & Atkinson: are robots taking our jobs, or making them?

Whereas Brynjolfsson & McAfee, though also Rifkin, highlight the rapid replacement of labour by machines and extensive automation, Miller & Atkinson (2013) of the Information Technology and Innovation Institute (ITIF) in Washington D.C. confront the issue by asserting that "robots are taking our jobs". Not only Brynjolfsson & McAfee, but also Paul Krugman, Richard Posner, Joe Stiglitz and Tyler Cowen and many other neo-Luddites[41] posit, according to Miller & Atkinson (2013), a highly misleading and inadequately fact-based correlation between high unemployment and technological development. They claim that such thinking takes no account of 'second-order' effects; in

41 After the Englishman Ned Ludd, who, during the industrial revolution, encouraged his followers to destroy the new textile machines of that time and thereby halt progress. The Luddites are often cited as one of the first to oppose the advent of new technology, automatic looms in the nineteenth century, which threatened to make them unemployed on a massive scale. A 'Luddite' or 'neo-Luddite' now denotes someone who is afraid of or opposes new technology.

other words the savings achieved by the increase in productivity are ploughed back into the economy, and spark an increase in demand, which in turn creates jobs. These savings flow back in three ways: via lower prices, higher wages for the remaining workers, and higher profits. Furthermore, our economy is so complex, with such a wide range of sectors and jobs, that although some cease to exist as a result of automation, most others remain. Technological change, however advanced it may be, does not take place overnight.

But the main reason that Miller & Atkinson see for robots not making us unemployed on a massive scale is that human needs are close to infinite. So long as that remains the case, labour will continue to be needed. According to Miller & Atkinson, productivity growth does not so much go together with the loss of jobs but rather with growth in employment, as statistics for the American economy for the period 1929-2009 convincingly show. In addition, the empirical link between the level of unemployment and productivity growth differs from what is assumed, and periods of all-time high productivity prove to be associated with all-time low unemployment.

The most powerful part of the argument put forward by Miller & Atkinson relates to the second-order effects, linked to the near boundlessness of human needs. The argument concerning empirical data and the parallel with earlier developments is perhaps less powerful. After all, Brynjolfsson & McAfee conversely claim that a break in the trend from the past is occurring. The argument that technology does not come overnight and that automation does not put an end to most jobs is a matter of fierce debate. For example, Frey & Osborne (2013), in their analysis of the impact of computerization on a wide range of existing jobs, estimate that 47% of employment is at high risk of automation, if not overnight, then at least over the next two decades (see also the Introduction, Chapter 5, and the conclusions described in Chapter 7).

Productivity growth and the role of technology in the coming decades: a summary

If we compare the various expectations for economic and productivity growth in the coming years, it is striking not only that there are sharp differences in growth expectations between important contributors to this growth debate but also that the arguments differ considerably.

Some, such as Summers and Krugman, see the cause of very low or even virtually zero growth (secular stagnation) in the lagging of demand, and in point of fact in a lack of investment relative to savings. This also puts pressure on technological innovation itself. Others, including Gordon, envisage productivity growth continuing in the coming years under the influence of technology and innovation. At the same time, they also foresee the occurrence of many headwinds crimping economic growth per capita in the coming decades.

An important point in the debate about productivity growth also concerns expectations for the extent to which increasing automation and robotization lead to the replacement of labour. Whereas some see huge cuts in labour at the expense of the lower and medium segments of the labour market (Brynjolfsson & McAfee; Frey & Osborne), others (Miller & Atkinson) forecast that things will not be so tough, and there are grounds for assuming that automation and robotization will, as a result of second-order effects, in turn lead to new jobs.

The last group chiefly stresses the prospects and opportunities that new technology offers, which may lead to extreme productivity growth and a period of unprecedented abundance (Rifkin; Kurzweil; Diamandis & Kotler). This group of technology optimists and futurists and their predictions are somewhat detached from the growth debate among economists. Nonetheless, it is essential to take these contributions seriously as well. The ideas of Rifkin, in particular, are popular, including among politicians, from Brussels to Berlin and Beijing.

There seems to be a certain consensus among most economists concerning the expectations we may entertain for potential future productivity growth; the group whose main exponents are Brynjolfsson & McAfee represents an exception here. Most economists generally assume calculations of growth from earlier periods, and notably the most recent period of the emergence of ICT and the internet, as an example of a spell of rapid productivity growth. In so doing, they commonly assume productivity growth of no more than 2% on an annual basis (Gordon 2012; Fernald 2012). The same order of magnitude is also evident in long-term growth projections by the OECD (2014a), with productivity growth being determined on the basis of growth accounting.

Thus, for the period 2014-2030, trend productivity growth of 1.9% is forecast for the Netherlands, as compared with 1.5% for the Eurozone, and 1.7% for the OECD as a whole. Trend productivity actually indicates the structural ceiling in the long term below which productivity can evolve. As important is the evolution of the potential employment ratio, which works out at -0.1% for the same period, chiefly as a result of ongoing population ageing. Trend productivity and the potential employment ratio together add up to potential GDP growth per capita, which is accordingly 1.8% for the Netherlands. This makes it clear once again that the Netherlands must in the coming years get by principally on productivity growth.

With regard to automation and robotization and their impact on jobs and economic growth, there has traditionally been a consensus among economists about the relationship between technological growth and the number of jobs in the short term. This relationship is negative; in other words, in the short term technological development comes at the expense of jobs. Over the medium term (one to two years), however, the consensus until 2010 was that new technology leads to new jobs relatively swiftly (the aforementioned second-order effects cited by Miller & Atkinson), which meant that the net effect was positive. In the last few years, this consensus has begun to crumble, not only among the criticasters Brynjolfsson & McAfee but also within the economic establishment, represented by economists such as Krugman, Posner, and Stiglitz. Thus, although there is a positive impact on labour productivity, the creation of new jobs (the 'jobs engine') is a weak point.

4.4 Policy options

Productivity growth does not lend itself to direct policy intervention. However, this does not mean that in terms of policy, we are standing empty-handed. For example, we can promote and facilitate the adoption of technology and innovation, as an important driver of productivity. And, more generally, actively foster a culture of innovation and renewal. Nevertheless, it is important that the policy measures follow an accurate diagnosis of the problem. This diagnosis has a factual side (how does labour productivity in the Netherlands evolve?), but also an expertise side (how and from what perspective is the diagnosis of the problem made?). The main thing is to arrive at an accurate diagnosis of the challenges ahead. And it is precisely this diagnosis that is tricky, as the foregoing demonstrates.

The need for labour productivity growth is evident. Whereas the Dutch economy was in past decades in particular able to grow through greater labour participation, in the coming years we will, with a shrinking working population and increasing population ageing, be reliant on growth in our labour productivity. If we look at developments since the crisis in 2008, the Netherlands has nevertheless lagged behind other countries substantially on labour productivity growth (MFP). The question is therefore how we can overcome this lagging trend.

In this context, the question is not so much whether new technology is available; the answer to this question is a resounding 'yes', given the technology developments of the last few years. Rather, the question is what 'our' investments should be directed at, and what they should be. Apart from investments in new 'tangibles' (improved capital goods, or capital deepening), investments in intangibles (including R&D, IP and design (innovative property) and all kinds of digital information such as software, databases, and so on) become ever more important for the growth of our labour productivity and also for our economy. This applies to industry, business services (trade, financial services), though also to other branches of economic activity, and also to the public and semi-public domain (public authorities, non-profit bodies).

Embracing ICT and the digital economy appears to be important for productivity growth, an area in which the Netherlands has to date performed well.[42] Nevertheless, there are also grounds for vigilance here. For example, a recent article in *Harvard Business Review* recently classified the Netherlands, based on digital economy characteristics and developments over the period 2008-2013, as a 'stall out' country, i.e. a country which is losing speed and momentum, with an impending risk of going backwards (Chakravorti et al. 2015). The reason that Chakravorti et al. adduce for this is striking: "The Netherlands, meanwhile, has been rapidly losing steam. The Dutch government's austerity measures beginning in late 2010 reduced investment into elements of the digital ecosystem. Its stagnant, and at times slipping, consumer demand led investors to seek greener pastures."

A key question concerning the adoption of new technology and innovation is: how do you link speed and energy to the successful reception and bedding-in of change? The speed of technological change, and the energy with which competing countries inside but especially also outside Europe, embrace such change, is forcing us to re-examine the issue of adoption. Is the Netherlands actually investing enough in new technology and innovation? Where would more investment be desirable? And what is standing in the way of such necessary change and renewal? Are our institutions, our laws and regulations, and also their application, sufficiently technology-proof? And how can public investments in technology and innovation sustainably contribute to a prosperous Netherlands, including in the future?

42 Interview with Bart van Ark.

Intermezzo

**Interview with
Bas ter Weel,
Maastricht University
and the Netherlands Bureau
for Economic Policy Analysis (CPB)**

Intermezzo

"Investing in education is the most important thing"

The evolving labour market is prompting investment and a fresh look at our education, claims Bas ter Weel, Deputy Director at CPB and Professor of Economics at Maastricht University.

While the higher-skilled seem to benefit from the emergence of technology in the labour process, this is more complicated for other groups. Machines have taken over some of the work of the lower-skilled, and now automation is also hitting the medium-skilled. This does not mean that this group of people has become unemployed on a massive scale. "Screwing things into other things is no longer needed, but demand for work in other sectors, such as personal services, is growing." However, this transition can be painful, and retraining takes time.

As a country, the Netherlands is highly skilled. People with *hoger beroeps-onderwijs* ('higher vocational education', oriented towards higher learning and professional training) are increasing in number and are currently experiencing less pressure from automation, unlike principally people with levels 2 and 3 of the four possible levels of *middelbaar beroepsonderwijs* (intermediate vocational education, oriented towards vocational training). People with level 1 intermediate vocational education and higher general secondary education always find it hard (and certainly during a recession). Those with level 2 and 3 intermediate vocational education who have work are vulnerable. "People with level 2 and 3 intermediate vocational education who are now in work are now actually 'stuck there'." Thus, someone aged 45 who has always worked for the same employer has little chance of new work and also few incentives to retrain. Technological developments are now continuing, and demand for the sort of work he does is declining. "If anything happens, this group finds it hard to get new work."

In Ter Weel's view, anxiety about mass unemployment is not necessary, but an appropriate way of investing in education is certainly needed. "Try to teach as many people as possible the right skills to get a new job." Despite all the innovations, skills such as counting, language, and factual knowledge are central to the Dutch education system. "The education system is in a way designed as if we – as it were – have just had the industrial revolution … the question now is whether this is the only thing that your children want to learn."

For example, combining information creatively is becoming more and more important, and education is, according to Ter Weel, currently inadequately geared to this. The current age also calls for skills in which people excel compared with computers. "For example, teach everyone to program, not as an end in itself, but as a way of becoming more skilled in combining information." A focus on more generic skills is also desirable. "Train as a maintenance engineer and leave the specialization, for example as a train or 3D printer maintenance engineer, to the employer."

Research by CPB reveals that personality and motivation are important predictors of job opportunities and pay. It is therefore logical to focus more on personality and motivation at school. Certain courses at intermediate vocational and higher vocational level should also be scrutinized to identify whether they meet the needs of the business community and offer the right incentives. "Now educational establishments are paid for each student coming into the system, with a diploma bonus, and yet hardly any attention is paid to whether that person actually lands a job with his or her diploma."

Apart from in education, changes on the labour market are also needed, according to Ter Weel. The number of workers with flexible work contracts (known in the Netherlands as 'flexwerkers', literally 'flex workers'), is growing. "On the one hand, employers need commitment (they don't want to wonder who's going to roll in tomorrow), but they also need flexibility. The permanent job has long been sacrosanct in the Netherlands – our institutions are geared to this." But the focus on permanent jobs has led to "overprotection of permanent jobs and underprotection of other forms of work."

In the Netherlands, people without a permanent job still come under a different system of arrangements, with all the uncertainty that this entails. The questions that arise from this are numerous. In Denmark, for example, a right to work instead of a right to a job is of key importance, and the incentive to find work quickly is much stronger. Is that a clever approach? We may then all have an incentive to work, but as low-skilled employees for only very low wages. Is that what we want? And if we do not, and agree on, say, a minimum wage of 20 euros per hour, unemployment will result. Differences in remuneration also incentivize people to invest in education. The question is therefore how do we as a society deal with the costs associated with redistribution?

One thing is certain: if researchers want to be able to make the right causal links, data must be provided in such a way as to make it possible to identify the link between ICT and the policy that labour market institutions pursue, explains Ter Weel. "We must measure things much better to know exactly what is going on."

5 The IT revolution and the labour market

Linda Kool

> *"No one goes to Paris to eat at McDonald's (…). But I was just one person in a long queue. To avoid waiting, people could opt to order their food using a touchscreen, pay for it with a credit card, and collect it from the counter – but they did not. Like me they preferred to wait and speak to the polite assistant (probably an undergraduate) at the cash till. Fastfood restaurants no longer need people at the counter, just as supermarkets don't need people to operate their checkouts. Technology can do these tasks. But these jobs still exist, largely because people need other people."* – Bainbridge (2015)

5.1 Introduction

Since the first industrial revolution, the accepted view has been that technology destroys jobs in 'old' sectors but quickly creates new jobs in new sectors to replace them. Hence, the lamplighter and ragman disappeared long ago, but were replaced by the engineer and the factory worker. And now, the IT revolution is creating a host of new occupations, such as software programmers, web designers, and online marketers.[43] A study by the OECD (1994, p. 2) accordingly concludes as follows: "Historically, the income-generating effects of new technologies have proved more powerful than the labour-displacing effects: technological progress has been accompanied not only by higher output and productivity, but also by higher overall employment." In our own times, the expectation within Europe that the 'app economy' will create nearly five million jobs by 2018 is entirely consistent with this thinking.[44] It is precisely for this reason that policy recommendations frequently put greater emphasis on the protection of workers than on the protection of jobs.[45]

Views on the relation between technology and productivity and economic growth. Brynjolfsson & McAfee (2014), for example, refer to the 'jobless'

43 Besides the question of whether technology destroys or creates jobs, the content of the jobs that remain also changes. Thus, the range of tasks that a secretary carries out in the year 2015 is incomparable with the tasks carried out by a secretary twenty or forty years before. This applies also, for example, to the job of an automotive engineer, where ICT takes over some of the workmanship.

44 http://europa.eu/rapid/press-release_IP-14-145_en.htm

45 See for example European Commission (2007) COM (2007) 359 final *Towards Common Principles of Flexicurity: more and better jobs through flexibility and security.*

growth that is currently discernible[46] – economic growth, admittedly, but not jobs growth – and see the recent wave of technological innovations as the prime cause of this.

This chapter looks at the influence of the IT revolution on the labour market: how does IT shape the composition of the labour market? Section 5.2 examines the recent past (roughly the last 15-20 years), in which the phenomenon of job polarization is of central importance: automation is taking over chiefly medium-skilled work, whereas demand for low-skilled, and in particular high-skilled, work is growing. Section 5.3 casts a look at the future: what is known about the potential future impact of the IT revolution on the labour market? Section 5.4 discusses what policy options the literature cites with regard to the relationship between job polarization and the possible future impact of IT on the labour market. In this context, the focus of this chapter is mainly on policy options in education. Other policy options to deal with growing inequality, in part as a result of job polarization, are discussed in the following chapter on prosperity. Chapter 4 reviews policy options targeted at the more general question of how government can play a part in creating more employment through the use of ICT.

5.2 Recent past

Job polarization

The influence of technological change on the labour market and its composition is not an easy issue to address. Labour markets change constantly, in response to various factors such as the economic situation (for example, growth or recession), demand for certain products, the organization of the production process, supply and growth of the working population (ageing, growing youthfulness, immigration), the skills that this working population has or needs (increase in the higher-skilled), but also technology and innovation (in the form of outsourcing, offshoring, or automation), and regulations. These factors may trigger changes in the demand and supply of labour, and bring about changes in the composition of the labour market (for example, a reduction in the proportion of low-skilled work), and changes in the structure of wages and functions. In view of the question that this research paper is intended to address, this chapter focuses mainly on the demand side of the labour market: how do automation and robotization influence the labour market?

A recent influential series of scientific articles (see, for example, Goos, Manning & Salomons 2014; Michaels, Natraj & Reenen 2014; Autor 2013; Acemoglu & Autor 2010) finds empirical evidence for the influence of the IT revolution on

46 Jobless growth is not in itself a new phenomenon, and is often evident after recessions (employment picks up later than economic growth).

the labour market since the 1970s. According to these articles, this has led to job polarization: demand for medium-skilled work is dwindling, whereas demand for high-skilled and low-skilled work is increasing.[47] The rationale for this is as follows: computers are increasingly able to take over routine cognitive tasks, such as administration, the performance of calculations, monitoring, or the assessment of products. This cognitive knowledge-based work is often medium-skilled work. This is connected with the rise of digital Taylorism, as described in Chapter 2: rethinking work processes and being able to split work into subtasks amenable to outsourcing, offshoring, or automation. The work of both the higher-skilled (such as software programming) and the lower-skilled (such as cleaning, catering, or hairdressing) is less routine and (for the time being) harder to automate.[48]

Skill upgrading

What is known as Skill-Biased Technological Change (SBTC) theory provides the theoretical background for the above-mentioned series of articles. This theory posits that the impact of technological change on the labour market is not neutral – in other words, not the same for all workers – but that technological change boosts demand for high-skilled workers (Violante 2008).[49] The argument is that technology replaces tasks that were first done by low-skilled individuals, while new technology calls for higher-skilled people to design, implement, and use the innovations (HCSS & TNO 2013). The theory predicts that technological change ultimately leads to *skill upgrading*: an increase in the skills of the entire working population. A contest arises, as it were, between technology and education, so that the working population is able to meet the demand for higher-skilled workers (Goldin & Katz 2008; Tinbergen 1975). Various studies demonstrate this increase in skills since the industrial revolution (since 1850) (Goos 2013; Katz & Margo 2013; Goldin en Katz 2008).[50]

SBTC theory cannot, however, explain the recent phenomenon of job polarization: why is demand for low-skilled work also rising? Down the years, SBTC has been the subject of various methodological criticisms (see, for example, Card & diNardo 2002). An important refinement by Autor, Levy & Murnane (2003) came in 2003. Up to that point, SBTC theory had adopted a simple two-way division of the labour market: unskilled/low-skilled work versus high-skilled

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47 The Netherlands Bureau for Economic Policy Analysis (CPB) has published a new study in June 2015, with figures up to and including 2009.

48 But ICT is also making inroads in these areas. High-skilled jobs will in future not be 'immune' to technological change. This issue reappears in section 5.3.

49 It is unclear to what extent this 'skill bias' has been present in history. For example, Acemoglu (2002) describes the early part of the nineteenth century as a period of '*skill replacing*'. Products previously manufactured by craftsmen were then made in factories by workers with relatively little training, which cut demand for higher-skilled workers.

50 This comes about partly as a result of huge investments in education between 1915 and 1980 (Goldin & Katz 2008).

work. Autor et al. adapted this theory, putting four types of tasks at its core (see Box 3). Their adaptation is called Routine Biased Technological Change (RBTC) or the 'routine model', and has subsequently been adopted by many other academics.

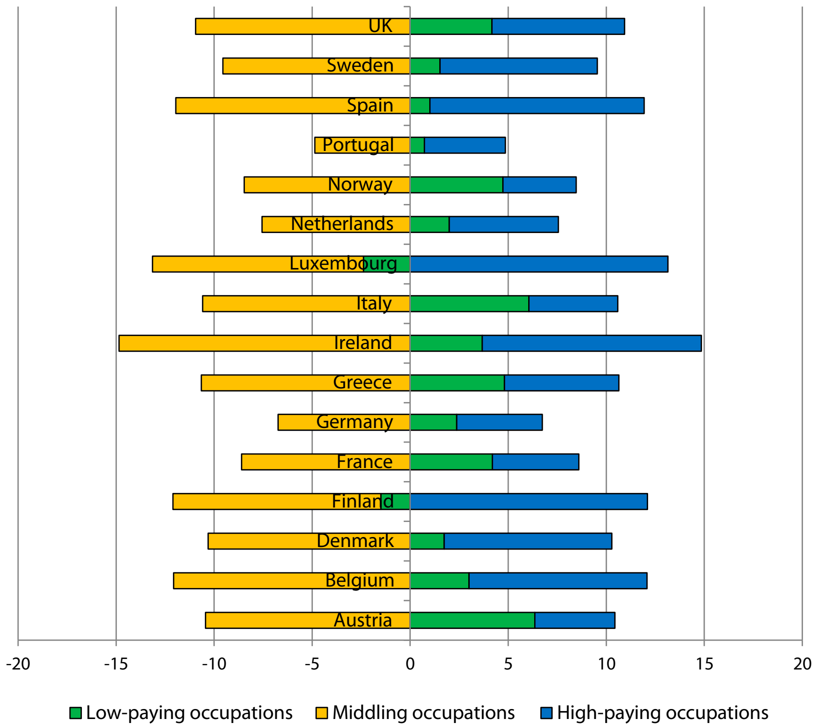
Box 3 The routine model proposed by Autor, Levy & Murnane (2003)

1. Routine work – manual (low-skilled): a lot of repetition of a physical nature. This is often unskilled work, and robots have increasingly taken it over since the industrial revolution.
2. Routine work – cognitive (medium-skilled): processing of information with a lot of repetition, such as administrative work. Until the IT revolution, it was difficult to do this work with machines/computers, but the use of machines and computers for this kind of work has increased since the 1980s.
3. Non-routine work – cognitive (high-skilled): work without a lot of repetition, in the production, processing, and manipulation of information, such as management, science, or other 'professional' jobs. Computers often complement the work of high-skilled people here.
4. Non-routine work – manual (low-skilled): work without a lot of repetition, physical in nature, such as maintenance work, bricklaying, or hairdressing. Although technology is also developing in this area, these are awkward tasks for computers to perform.

Autor, Levy & Murnane (2003) found in the United States that computers indeed took over routine cognitive work from people, but did not yet conclude that job polarization was taking place, talking still of skill upgrading.

It was not until 2007 that job polarization was described and dubbed as such, by Goos & Manning, on the basis of data from the United Kingdom since the 1970s. Based on the 'routine model', Goos & Manning identify an increase in jobs at the upper and lower ends of the labour market, at the cost of medium-skilled work. In 2009, and more recently in 2014, Goos, Manning & Salomons show (with data for the period 1993-2010) that job polarization has been going on throughout Europe (see Figure 5). They call this pattern 'pervasive', and identify technological change as by far the most important cause – more important than for example offshoring. In the United States, too, academics identify job polarization, the explanation for which lies in computers taking over routine cognitive work (Acemoglu & Autor 2012; Acemoglu & Autor 2011; Autor 2013; Levy & Murnane 2013).

Figure 5 Changes in the share of employment in percentage points by skill group and country, 1993-2010



Source: Goos (2013).

The Netherlands Bureau for Economic Policy Analysis (CPB) (2012) finds that job polarization is also going on in the Netherlands. According to CPB, the composition of unemployment in the Netherlands has changed as a result of rising demand for high-skilled individuals and the dwindling of employment options for medium-skilled workers: "What is striking in the current recession is that mainly people with intermediate levels of education and training have lost their jobs. This is a phenomenon that occurred barely, if at all, in previous recessions. In the 1970s and 1980s, it was mainly a lot of jobs at the bottom end of the labour market that disappeared, and the army of unemployed people consisted of people with relatively low levels of education and training" (CPB 2012, p. 5). There is less of a need for lower levels of intermediate vocational education (levels 1, 2 and 3), but more of a need for workers with level 4 intermediate vocational education.[51] Allowing for various causes, such as technology, globalization, changes in the supply of low-, medium-, and high-skilled people on the labour market, and institutional factors (such as the role of trade unions or minimum wages), CPB finds that technological change is the main driver of job polarization in the Netherlands.

Many studies regard the advent of the IT revolution and the routine model as the main cause of job polarization. But globalization (and notably offshoring) also plays a part. For the United States, Elsby, Hobijn & Sahin (2013) identify offshoring of the labour-intensive part of the value chain as the main cause. Offshoring marks an important step towards the replacement of labour by computers (Levy & Murnane 2013; CPB 2012): if you can codify work (capture it in rules, such as a telemarketer's script in a call centre), you can readily relocate it. Precisely this codification is an important step in subsequently getting a computer to do the work.[52] By contrast, the personal side of services in turn makes the relocation of work, or automation, more difficult (Blinder & Kruger 2006). This cuts right across sectors and professions: the work of radiologists in the healthcare sector is easier to relocate, because there is less direct patient contact, than the work of, say, paediatricians.

Questions about job polarization

Job polarization is a reasonably robust scientific finding, but its precise measurement remains tricky. There are, for instance, various measurement methods based on aspects such as wages or evolution of employment. In the Netherlands, job polarization is principally evident in evolution of employment, but less so in wages (for example because institutions play a role in the redistribution of income).[53] Mishel et al. (2013) find, in the United States, that demand for work in the intermediate segment has been declining since the 1950s, but think that SBTC theory and the routine model are unable to explain the changes in wages adequately. They prefer to talk about *occupational upgrading* because they chiefly see a contraction of the intermediate segment and an increase in the high-skilled segment; the proportion of low-skilled work is growing, but only minimally, and continues to account for a relatively small part of the overall labour market.

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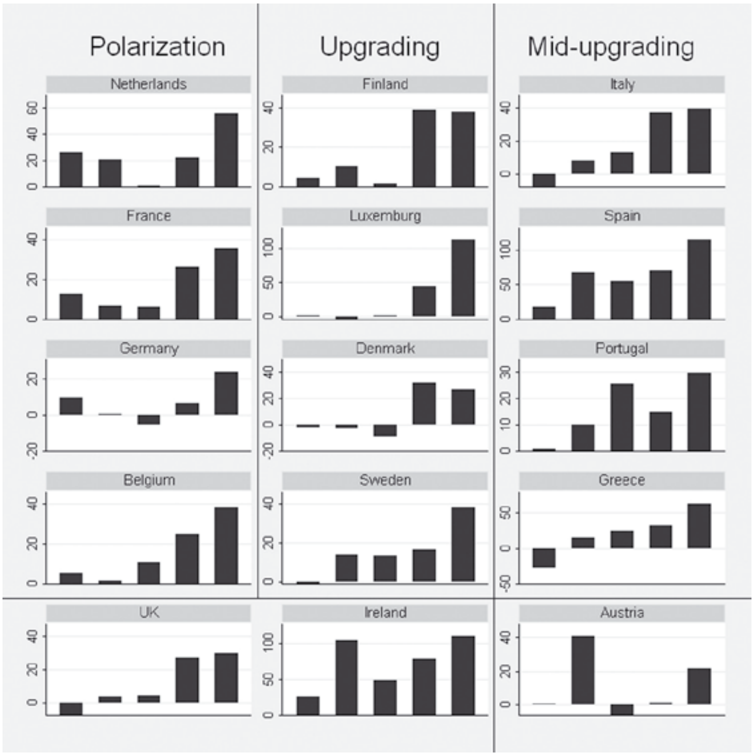
51 Interview with Bas ter Weel. The group of people with level 2 and 3 intermediate vocational education is shrinking, but is still large. The group of people with level 4 intermediate vocational education is growing. The group of people with level 1 intermediate vocational education always has it tough, and has found things even tougher during and after the recession.

52 Chapter 2 shows that reorganization of the environment is also an important step prior to codification and digitization.

53 Interview with Bas ter Weel.

Figure 6 Relative differences in employment in training quintiles (Fernandez-Macias 2012)



Source: Fernandez-Macias (2012)

There are also differences between countries. In studies by Goos et al. (2014), Michaels et al. (2014) and CPB (not yet published), the Netherlands displays a relatively modest pattern of polarization relative to other countries. According to a study by Fernandez-Macias (2012), the Netherlands is one of the countries with a high degree of polarization. Fernandez-Macias identifies three patterns in Europe for the period 1995-2007, namely job polarization, skill upgrading, and in some countries the opposite of job polarization: an increase in medium-skilled work at the expense of low-skilled and high-skilled work (see Figure 6). Fernandez-Macias explains the differences with the aid of institutional factors, such as differences in the degree of flexibilization of the labour market, set minimum wages, or the existence and strength of trade unions. In the Netherlands and Germany, deregulation of the labour market has led to an increase in flexible contracts for low-skilled workers. This is one of the causes of growing demand for work for the lower-skilled. According to Fernandez-Macias, the Scandinavian countries and Luxembourg have strong trade unions and a more homogeneous wage structure; this could explain the pattern of skill upgrading in those countries. With regard to the countries of Southern

Europe, the author refers to the looser financial conditions that occurred after accession to European Monetary Union, which sparked a huge expansion in medium-skilled work, notably in the building sector.

5.3 Prognoses for the near future

It is uncertain how demand for labour will evolve in response to future technological developments: after all, no data are available. Nevertheless, there are various visions, or speculations, about the future and about whether, and to what extent, machines will take over the work of humans. Brynjolfsson & McAfee (2014) and also, for example, Ford (2009; 2015) assert that machines will replace humans much more than in the past. In the view of these authors, the balance between job creation and job loss has now shifted towards the latter. But their view is not unchallenged. Miller & Atkinson (2013) think that they systematically overestimate the speed of technological developments – and the scope of technology to take over human tasks. Consider, for example, the debate about how long Moore's Law will hold. For how long can computing power double every eighteen months, and when will a transition to other technologies occur (see also Box 2 in Chapter 2)?

Dancing with robots
At the present time, computers are mainly taking over medium-skilled work. Various studies expect that this polarization trend will continue in the coming years and that computers will increasingly be able to take over routine work (Dolphin 2015; Levy & Murnane 2013). Levy & Murnane (2013) expect in their study 'Dansing with robots', based on the routine model of Autor et al. (2003), that the future of work will consist of three non-routine, cognitive tasks: 1) solving unstructured problems, 2) working with new information, and 3) performing non-routine physical work. In these tasks, humans will work together with the computer, and will complement one another as far as possible. An example is a doctor who receives assistance from a software program in making a diagnosis. A German study, conducted on behalf of the *Bundesministerium für Wirtschaft und Energie* (Federal Ministry for Economic Affairs and Energy) (2014), also posits various forms of complementary interaction between humans and machines, for example one form in which humans instruct the machine on equivalent forms of cooperation ('the robot as colleague'). The expectation is also that work with a personal component will (in part) remain (Levy & Murnane 2013; Bainbridge 2015; Blinder 2006). The remaining work, usually routine work, will, according to Levy & Murnane, be done by computers or in low-wage countries. They cite a prediction for 2020 from the United States Bureau of Labor Statistics in support of their hypothesis. According to this study, the job polarization trend will continue, and routine work, of a cognitive nature, will be increasingly replaced. The Bureau expects the greatest growth in healthcare, technical and mathematical occupations, social welfare work, and construction.

However, high-skilled and low-skilled work may not be 'immune' to automation: "Do-it-yourself kits, for instance, potentially substitute for the roles played by lawyers in conveyancing, divorces and making wills. And intelligent, automated systems have some capacity to squeeze out jobs at the bottom of the occupational hierarchy too" (Hogharth & Wilson 2015, p. 21). According to WRR (2013, p. 152), automation may in future have consequences for all levels of education and training: 'It will be possible to automate rules-based operations ever more extensively, but communication and complex problemsfolving will for the time being remain the work of humans.'

Box 4 Occupations of the future

A workshop held on 3 October 2013 on the occupations of the future, organized by BrilliantBrains and the Hague University of Applied Sciences, considered occupations that are more or less a logical consequence of technological developments, notably in ICT.

The following are a selection of possible future occupations:
3D-printing expert, 4D-printing architect, augmented reality designer, big data visualizer, chip implanter, data visualization specialist, DNA technologist, drone technician, drone catcher, robot intelligence ethicist, extended brain specialist, food designer, game developer, digital tool developer, minifood grower, organ developer, robot developer, robot service engineer, robot therapist, security identity expert, smart home designer, smart grid designer, language and speech technologist, virtual travel agent, virtual driving and flying instructor, virtual world designer, and leisure coach.

Source: Smeulders, R. & Prins, R. *Beroepen van de toekomst.*

Frey & Osborne published in 2013 – as referred to above – a much-discussed and controversial study in which they assume that computers will in the future also take over non-routine cognitive tasks from humans. Apart from methodological questions, the study does not say anything about whether that is actually happening (for example, owing to social acceptance or cost-benefit analysis) or what possible new jobs will come along.

Frey & Osborne think that 47% of the existing 702 'types' of jobs are highly susceptible to automation over the next two decades. In their view, manufacturing, sales, construction[54], and services (including personal services), are

54 The study by the Bureau of Labor Statistics nevertheless expects growth in the construction sector.

sectors in which employment will fall.[55] Deloitte (2014) projected Frey & Osborne's results to the Dutch situation and expected that principally administrative and low-skilled service functions are at risk. The expected impact will be great for salespeople, accounting personnel, and construction workers. At higher vocational education and graduate level, specialist occupations (surveyors, laboratory technicians, supervisors) and specialists in business management (accountants, analysts) are at risk, according to Deloitte. Vulnerability is greatest in engineering, agriculture, economics, law, and management. The Brussels think tank Bruegel (2014) ran the figures for Europe as a whole on the basis of Frey & Osborne's study and found that 49.5% of jobs in the Netherlands are susceptible to automation. This figure is comparable with that for other Northern European countries (Belgium, Germany, France, the United Kingdom, Ireland, and Sweden) and for the United States.

Globalization

The question of jobs of the future is bound up with where these jobs will be located. What does the ever-growing globalization – which, in turn, the IT revolution has made possible – mean for the place where work is created? Globalization and the advent of global value chains are prompting the elimination[56] and relocation of jobs.[57] According to Brown et al. (2008; 2014), increasing globalization is also sparking worldwide competition on skills between workers (see also Chapter 2). This means that high-grade jobs can also be done at low-cost locations. At the same time, the increasing number of high-skilled workers is also creating opportunities.[58] The Netherlands can tap the potential of more high-skilled individuals, with Dutch businesses also employing international knowledge workers. This increases the importance of the clustering of activities that are attractive to enterprises and workers.

Skills

Technological innovation is transforming demand for skills, prompting debate about a potential looming 'skills mismatch'. A skills mismatch is, however,

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55 Using completely different methods, Elliot (2008; 2014) arrives at even higher figures. He concludes that 81% of jobs are susceptible to automation. Despite the experimental nature of his study, he considers that new methods are needed to be able to assess the impact of IT on the labour market accurately because the fast pace of technological developments is, in his view, unprecedented.

56 Autor, Dorn & Hanson (2013) show, for example, that growing import competition with China led to manufacturing in the USA shrinking by a quarter between 1990 and 2007.

57 For years, a trend was discernible in which production work and elements of R&D work were shifted to low-wage countries (offshoring). A trend is now apparent for returning the work to the country of origin (reshoring). Some people think that a quarter of current jobs in the United States are amenable to outsourcing. These are mainly jobs for medium-skilled people. Nevertheless, high-skilled workers also score high on potential for outsourcing of some of the work (CPB 2012).

58 Interview with Bas ter Weel.

difficult to gauge.[59] For example, there is uncertainty about expectations for a qualitative mismatch – a possible shortage of personnel with specific, often technical skills. The findings of studies at macro and micro level are contradictory (Gijsbers 2014, p. 6): "(…) we are seeing a major contradiction between macro level studies that overall no major shortages of high-skilled labour are to be expected and industry and sector level studies which emphasize urgent problems being faced by industry in finding workers with right skills and competences. This contradiction is not easily explained and requires further research. One possible explanation may be that labour markets are not functioning as well as they should and do not match supply and demand very effectively. Limited mobility of skilled personnel may contribute to the mismatch."

Concerns also exist about under- and over-qualification. An OECD study from 2011 indicates that both kinds of mismatch exist in Europe: "(…) in the OECD on average, about one in four workers are over-qualified - i.e. they possess higher qualifications than those required by their job - and just over one in five are under-qualified - i.e. they possess lower qualifications than those required by their job" (Quintini 2011, p. 4). According to British academics at the Institute for Employment Research, competition for low-skilled work in particular is growing: "There are, for example, an increasing number of highly qualified people in elementary occupations which typically do not require such a level of formal qualifications" (Hogarth & Wilson 2015, p. 21). People with more qualifications are better able to find and retain jobs and thus push other, lower-skilled people out of the labour market: a process of 'downward displacement'. The British academics can also see the impact of globalization and technological innovation, which is cutting demand for medium-skilled work and raising demand for high-skilled work, with little change in demand for low-skilled work.

Job polarization may also be interpreted as a form of skills mismatch (HCSS & TNO 2013): demand for high-skilled work increases faster than supply, while demand for medium-skilled work falls faster than its share in the labour market. An important question for the future is whether workers will be able to acquire new skills quickly enough to find work where there is demand.

5.4 Policy options: race between education and technology?

This chapter has reviewed various academic insights concerning the influence of technological change on the labour market. The conventional view since the industrial revolution (the first machine age) has been that new technology destroys jobs, but that new (and often better) jobs always take their place.

59 For an overview of various kinds of skills mismatch, and a discussion of various methodological questions, see for example ILO 2014 or Quintini 2011.

Technology was skill upgrading: it demanded more skills from everyone. Heavy investment in education has also allowed better training of people to meet this demand for new, better skills (Goldin & Katz 2008). In the past, it has therefore always been education that has won the 'race between technology and education'.

But since the advent of the second machine age, in which machines provide thinking power and where digital Taylorism (see Chapter 2) makes it possible to split routine cognitive work into subtasks and offshore, outsource, or automate it, a pattern of job polarization has become evident. Demand for medium-skilled, routine cognitive work has fallen, while demand for high-skilled and (to a lesser extent) low-skilled work is rising. Mainly higher-skilled people seem to benefit from the IT revolution.[60] This may lead to 'downward displacement' (Hogarth & Wilson 2015) in which the middle segment starts competing with the lower end of the labour market.

Expectations for the future are unclear: the pace of technological developments is uncertain, and academics also differ in their views about the extent to which technology is taking over the work of humans. Nevertheless, various studies assume that the polarization trend will continue and that both low-skilled and high-skilled work will also be amenable to automation (examples include interpreters, certain functions in the legal profession and accountancy, and Artificial Intelligence web design).[61] Many policy options also now indicate the importance of education, and this section lists those cited in this context. Further research is needed to formulate concrete policy recommendations.

Retraining, further training, and on-the-job-training
Education is important to ensure that everyone – including the middle segment now mainly hit by automation – acquires new skills and will find new work again. This may be a painful transition for some groups. Goos (2013) expects that so long as countries carry on investing in education and on-the-job-training, the growing demand for higher-skilled work can be met, and the skill upgrading effect of technology and economic growth can continue. Retraining and further training are important, but slow. In the Netherlands, these processes take place mainly via the influx of young people onto the labour market. People with level 2 and 3 intermediate vocational education are vulnerable to technological change: if they are made redundant, they find it difficult to get new work, and the consequences for, say, their wages or retirement may be considerable.[62]

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60 Job polarization may still also be skill upgrading. According to Goos (2013), skill upgrading is still taking place 'in net terms'.

61 See for example the automatic web design site The Grid, https://thegrid.io.

62 Interview with Bas ter Weel.

In connection with job polarization, CPB (2012) refers to the importance of the middle segment moving into higher-skilled jobs, and boosting the adaptability of workers: workers with more generic capabilities can switch more easily between companies and sectors at the time that – for whatever reason – demand on the labour market is changing. This is achievable through, for example, job rotation and investment in on-the-job training. Goos (2013) discusses various academic studies that find empirical evidence for the importance of HR policy and being able to make optimal use of ICT. Important elements of such HR policy are self-managing teams, job rotation, and training in skills such as cooperation and information sharing. Creating more adaptability on the part of workers requires the cooperation of employers, workers, educational establishments, and government. According to Cedefop (European Centre for the Development of Vocational Training), countries with less of a skills mismatch are those in which companies pursue better personnel policies and offer higher-grade jobs (Cedefop 2015).

Greater interaction between businesses and education is considered important in preventing a skills mismatch as far as possible. Educational establishments may, for example, involve businesses in the design of curricula, while businesses and educational establishments can set up strategic relationships (Salomons 2015; UKCES 2014). Closer coordination may also take place on the more generic skills that are central to educational establishments and more specific skills that employers would like their workers to learn. Brynjolfsson & McAfee stress the importance of the advent of new online 'matching services' such as LinkedIn,[63] in bringing about a better match between demand and supply of work. The emergence of *Massive Open Online Courses* (MOOCs) may also be seen as important in ensuring better access to higher education which is affordable (Bainbridge 2015; Brynjolfsson & McAfee 2014).

Primary and secondary education

Other policy options focus on training a variety of generic skills as part of primary and secondary education. Examples include skills in which people differ from computers – such as working with new information, combining information and unstructured problems, creativity, and interpersonal skills such as communication – and also skills compatible with increasing flexibilization and a digitizing environment, such as metacognitive skills (learning to learn), entrepreneurship, and e-skills, such as learning to code, program, 3D-print, and so on.

63 New online services such as TaskRabbit (an online marketplace for the United States in which people can offer their services locally to others) may play a part here.

More initiatives are appearing (including in the Netherlands) to teach children how to program at an early age[64] and familiarize them with entrepreneurship.[65] In part, these are skills dubbed as 21st-century skills: conceptual and metacognitive knowledge and skills in communication, cooperation, sociocultural awareness, and ICT skills (see for example SLO 2008).

CPB (2014a) shows that personal development and motivation are also important skills; they are important predictors of socioeconomic outcomes, such as the chances of landing a job, the pay that someone earns, and the number of years invested in education. CPB therefore advocates bolstering the focus on these skills in the educational curriculum. The OECD's Skills Outlook (2013a, p. 23) shows that by no means everyone has these skills:

- "In most countries, there are significant proportions of adults who score at lower levels of proficiency on the literacy and numeracy scales.
- In many countries, there are large proportions of the population that have no experience with, or lack the basic skills needed to use ICTs for many everyday tasks.
- Only between 2.9% and 8.8% of adults demonstrate the highest level of proficiency on the problem solving in technology-rich environments scale."

A scenario study by the UK Commission for Employment & Skills (2014)[66] forecasts that work will in the future become more flexible, and that workers will accordingly be expected to have more self-management and business skills, such as project management and the ability to promote oneself. A portfolio of other skills, including "*Personal agility and resilience, such as the ability to adapt to or embrace change is important within this context.*" The McKinsey Global Institute (2012) also highlights cooperation, problem-solving, a good command of language, project management, and good communication skills. Business and entrepreneurship skills encompass data analysis, value chain management, financial and personnel matters, and intellectual property (Gijsbers 2014).

At the beginning of 2015, in the Netherlands, the State Secretary for Education, Cultural Affairs and Science launched the Platform #Onderwijs

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64 See for example the Hour of Code, http://hourofcode.com.nl and the RoboMind Academy, http://tegenlicht.vpro.nl/nieuws/2014/november/programmeren-in-nederland.html. In England, programming has formed a compulsory part of the national curriculum since September 2014, see http://www.bbc.com/news/education-26061864.

65 See for example the entrepreneurship programme for primary education, http://www.jongondernemen.nl/bizworld.

66 The Commission consists of representatives of the business community and trade unions, and is publicly funded, https://www.gov.uk/government/organisations/uk-commission-for-employment-and-skills/about.

2032.[67] The platform focuses on the skills that children going to school in the year 2032 will need to learn in order to be properly prepared for the evolving society and labour market that rapid technological developments will bring about.[68] Brainstorming that started at the end of 2014 also uncovered the above kinds of skills: knowledge for learning and work (entrepreneurship, learning to learn), personal development (creativity, mindfulness, new perspectives), and social development (digital literacy, freedom of expression). The platform will further elaborate these categories in the coming months.

67 Parliamentary Papers II 2014/2015 31 293, number 232; Parliamentary Papers II 2014/2015 31 293, number 226.

68 http://onsonderwijs2032.nl/

Intermezzo

Interview with
Fabian Dekker,
Erasmus University Rotterdam

Intermezzo

"Start a broad public debate, also outside the discussions in the government in The Hague"

It is simply undeniable: inequality in the Netherlands based on the type of work contract and as a result of technological innovation is growing. It is high time for a broad discussion within society about such things as possible policy options, thinks Fabian Dekker, a researcher at Erasmus University Rotterdam.

A debate is going on about rising levels of income and wealth inequality in the Netherlands. Existing institutions and social security arrangements, at least in part, subdue income inequality in particular. "But institutions are not well enough suited to dealing with quality of work, or the security of having work." Flex workers do not score well on aspects such as job insecurity, autonomy, and learning opportunities, explains Dekker. "The important question for the future is whether we will get a sharper divide between this kind of 'flex work' and permanent employment."

A single kind of flex worker does not exist, stresses Dekker, but there is an above-average frequency of part-time, agency, temporary, payroll work, and work based on zero-hours contracts being done by young people, the elderly, the low-skilled, women, and non-western, foreign-born migrants. And although the growing ranks of self-employed people are largely 'happy workers', they also experience problems, such as mental stress or insecurity about the future. As Dekker explains, "In the long term I'm expecting serious problems, certainly given the high level of underinsurance."

Technology is partly responsible for the greater use of flexible working arrangements, but other factors are also at play, including the reduced role of the trade unions, the increased openness of economies, and the deregulation of social security. In Dekker's view, the current debate should focus on the effects of automation instead of on potential future consequences of robotization. He cites an acceleration of the effects of automation since the 1980s. Whereas the adverse effects of automation mainly struck the low-skilled as from 1980, now they are also increasingly afflicting the medium-skilled, particularly those with levels 2-4 of intermediate vocational education. "These groups are now at greatest risk of becoming unemployed." The position of the low-skilled is worsening as a result of structural downward displacement by high-skilled workers. Because although new technology raises demand for the high-skilled, there is insufficient capacity to absorb people with higher qualifications. They therefore accept work previously done by people with less education.

For Dekker, flex work is at odds with innovation; in his view, it does not lead to more R&D spending, and nor is it the engine of jobs that people think it is. The debate about policy options, including those of an unconventional kind, for dealing with the consequences of automation therefore fascinates him deeply: "It is important to subdue the adverse effects of flex work as far as possible." An example could be a 'transition aid' that people could access when changing jobs or at times of inactivity, though also to facilitate care tasks and paid work. Some put the emphasis on learning and being able to program. "But I think that handling big data, being able to interpret data, those kinds of analytical and creative skills, are more important. It's in those kinds of skills that I expect people to do better than technology. That's all 'tacit knowledge': we often don't know what we can all do."

The OECD (*Employment Outlook 2014*) is thinking about the 'single labour contract' to reduce the growing divide between flex workers and those in permanent employment. "That gives everyone the same contract, a kind of zero-hours contract, and you accrue rights each day you work. Young people, too, can accrue rights that way. The beginning is therefore a level playing field. But it also means individualizing the social system."

Looking at innovation, it is worth treating flexible personnel as though they were permanent employees, explains Dekker. "This means fairly basic things like invitations to company outings, performance interviews, on-the-job training, and careers guidance. Flex workers are not given enough tools to be mobile." However, there is scarcely any debate about why employers fail to invest in flexible personnel.

According to Dekker, this is still a subject for, at best, only limited discussion. He advocates a broad debate within society about the impact of automation on various groups on the labour market. How do we want to organize future society? What opportunities do we give people? What do we do with people who end up permanently in flexible arrangements or are otherwise unable to cope? Do we think this is a problem and, if so, what do we do? "That shouldn't just be left for central government in the Hague." Dekker feels that the evolving labour market calls for labour contract-neutral arrangements based on people's capabilities and to which the business community also contributes. "There is currently a lot of emphasis on the individual's responsibility and his or her employability. But what is the joint responsibility? And what is the role of the employer?"

6 IT and prosperity

Govert Gijsbers

This chapter examines the relationship between IT and prosperity: how does IT influence our prosperity, or, more specifically, how does IT influence our opportunities for acquiring income and wealth? IT ensures changes in our economy in many ways. For example, IT investments may trigger changes in employment and pay, but also bring about lower production costs, and thus cheaper products. In addition, the production capacity that labour-saving IT frees up and the income that IT generates, or some of it, can be deployed in other parts of the economy ('second-order effects', see Chapter 4), thereby allowing a rise in general prosperity. This chapter sheds light on the relationship between IT and prosperity with the aid of four secondary questions. We start with the question of what concepts are important in the relationship between prosperity and IT (6.1). We then examine what changes in prosperity have actually occurred in the past decades (6.2). A logical follow-up question is: to what extent and in what way is technology responsible for prosperity and its evolution, both now and in the future (6.3)? And finally: what options are available for policy (6.4)?

6.1 Definitions and terminology

Distribution questions have to do with equality and inequality. In this context, a distinction is often made between equality of opportunities ('equal opportunities') and equality of outcomes (Kremer et al. 2014). Both are important. All manners of redistribution measures achieve a certain level of equality of outcomes, via taxes, grants, benefits, and surcharges. Equality of opportunities, including equality of opportunities for development, is, according to Pels (2009, p. 2), important for social cohesion: "… such clearly working equality of opportunity is the best way of 'holding the whole thing together'."

Both aspects are concerned in the relationship between technology and inequality. In equality of opportunities, the debate about the 'digital divide' is important; most attention, however, goes to questions about outcomes. Material distribution issues (income and wealth) are important in this regard, but so too are aspects such as quality of work and job security.

Before incomes and wealth can be shared, they must first be earned and built up. Section 2 therefore examines, based on the available statistics, how remuneration for labour (wages/incomes and capital (profits and wealth) has evolved in past decades. Before that, we discuss the distribution of national income between labour and capital (the labour income share). With regard to income distribution, we can distinguish between gross or primary income distribution and net or secondary income distribution after taxes, social security contributions, surcharges, and the like (Kremer et al. 2014; Ostry et al. 2014). Various measures are available for gauging income and wealth distribution. An example is the Gini coefficient; although this provides a summary in the form of a numeral (0-1); it provides no understanding of the distribution between the upper and lower ends (the top and bottom 10% of the population or the question of 99% versus 1% of the population).

The distribution of incomes and wealth between the low-, medium-, and high-skilled is important owing to observed job polarization on the labour market in relation to technology, knowledge, and skills (see also Chapter 5). It is also important to look at spatial inequality in incomes and the evolution of wealth: growth and contraction are discernible in the Netherlands (the Randstad conurbation versus the 'periphery'), while there is also strong global technology-driven growth in a small number of regions (for example, in Silicon Valley), which are generating huge fortunes.

There is inequality not only between regions and countries but also between generations, with great and growing differences in the Netherlands and elsewhere between the baby boom and post-baby boom generations. In addition, it seems that heredity is in turn again becoming more of a determinant of the distribution of wealth (*The Economist* 2015a). For the Netherlands, the Netherlands Institute for Social Research (Bovens et al. 2014) finds that, besides inequality, segregation (particularly in housing and education between the higher- and lower-skilled) is rising.

What role does technological change (chiefly in IT, automation, and robotics) play in questions concerning the distribution of income and wealth? It is not easy to establish this relationship because, as the foregoing chapters have made clear, factors other than technology are also involved in the growth of productivity and the distribution of prosperity. Offshoring is triggering the disappearance of production jobs. Globalization and offshoring of production are also closely connected with technological development and therefore partly driven by it, which makes it difficult to differentiate between the two. Furthermore, the recession since 2008 has had a major impact on growth and the distribution of incomes and wealth (including via rising unemployment), which makes it difficult to clearly identify the role of technology.

6.2 Distribution of prosperity 2000-2014

This section describes certain aspects connected with the distribution of prosperity in broad terms. First of all, the focus is on what share of national income is accounted for by the factor labour, continued by the income and wealth distribution. This is followed by a brief discussion of how inequality evolves between regions, in the Netherlands and elsewhere, and also between the generations. Finally, we look at more qualitative aspects that have more to do with well-being: developments in quality of work, job security, and prospects for the future.

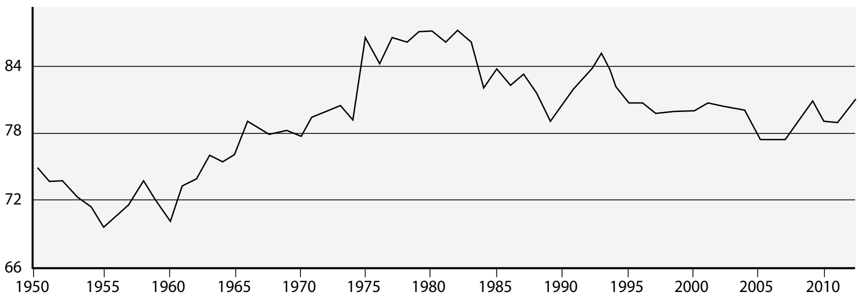
The factor of labour in national income
Internationally, changes in remuneration for the factors of labour and capital are the subject of close scrutiny (OECD 2012). In many countries, it seems that the share of national income that labour accounts for is falling at the expense of the return on capital. In the United States, Brynjolfsson & McAfee (2011) refer – as already mentioned in Chapter 4 – to the great decoupling. Until around 1990, labour productivity and incomes evolved in the same way, but since then productivity growth has ceased to be translated into a rise in household incomes.[69] For the United States, Elsby et al. (2013) find that offshoring of the labour-intensive elements of the production chain accounts for most of the pressure on wages. Moreover, liberalization of the labour market and investment in new labour-saving technology play an important part.

The OECD (2012) has been observing a fall in labour's share of national income (the labour income share) for the last 20 years, namely from 66% to 62%. The OECD cites four contributing factors. Firstly, technology allows highly productive new investment that is not only profitable but also permits the replacement of labour by capital.[70] Secondly, there is increasing global competition, particularly from low-wage countries. Thirdly, the power of trade unions that defend their members' interests is waning. A final factor is that liberalization of the labour market has taken place in many countries. In the Netherlands, too, the labour income share has fallen in recent decades (1980-2010) (Figure 7) – although there are differences between periods.

69 A publication qualifying this (Pessoa & Van Reenen 2012) distinguishes between gross and net decoupling – under the latter, the analysis takes account of the rising value of secondary labour conditions, thus leaving a smaller net decoupling.

70 More specifically, the OECD refers to an increase in *total factor productivity* (TFP) and in *capital deepening*; both are strongly related to the development and application of technology (see also Chapter 4).

Figure 7 Labour income share of the market sector in the Netherlands, 1950-2012.



Source: Kremer et al. 2014, p. 144

A fall in the labour income share means that productivity growth does not benefit the production factor labour, but benefits the production factor capital.[71] In the Netherlands, the moderation of wages that has been going on for years and also the lower taxation of wealth plays a part in this. A study by De Nederlandsche Bank (Eggelte et al. 2014) demonstrates that the labour income share in the Netherlands is high compared with other countries (around 80%). If we look at recent developments, it is striking that real available income since the crisis has been under heavy pressure because "the incomes of self-employed people have dropped sharply, wages have risen more slowly, unemployment has picked up, costs have risen, and inflation has been driven up by cost price-raising taxes and rising energy prices" (Eggelte et al. 2014, p. 27). Recently, inflation has fallen back again, partly as a result of falling energy prices.

Gross and net income distribution

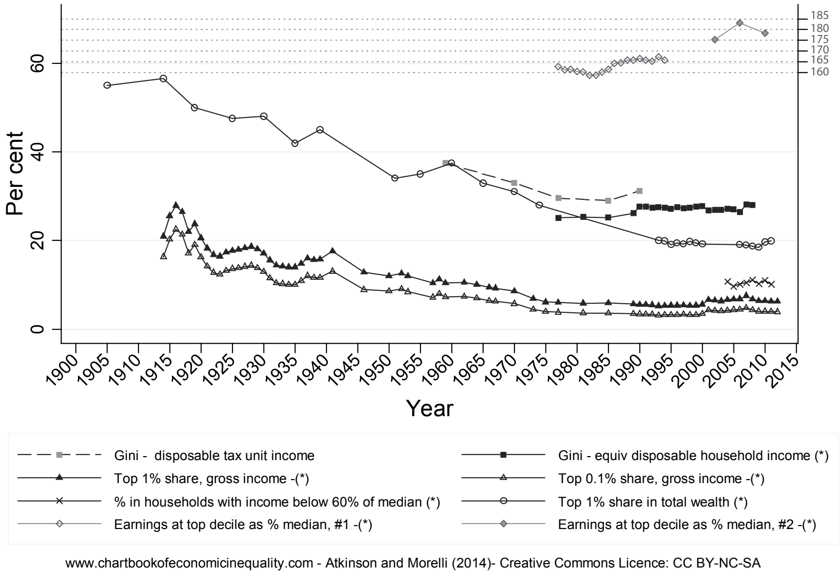
Whereas the relationship between labour and capital was central to the preceding section, this section focuses on remuneration differences within the factor labour. The most well-known measure that expresses the distribution of income and wealth in a single numeral is the Gini coefficient. This assumes a value of 0 in the case of a completely equal distribution, and a value of 1 in the case of a completely unequal distribution.

The *Chartbook of Economic Inequality* (Atkinson & Morelli 2014) provides a historical overview of different measures of inequality for a large number of countries. For the Netherlands, the chartbook also presents data on income inequality, namely the Gini coefficient, the share accounted for by the top 10%

71 The impact of this on workers, their purchasing power, and consumption is not unequivocal and depends on various factors (for example, whether wages form the main component of consumer incomes, and the potentially improving competitiveness of companies, which can use the increasing profit for investment).

and 1% of incomes, poverty (the lowest 20% of disposable incomes), personal incomes, and wealth (top 1%) (see Figure 8). The conclusions are that income inequality fell between 1959 and the mid-1980s, that income inequality has remained 'relatively stable' since the 1990s, that the top 1% share of wealth dropped during much of the twentieth century and then levelled off, and that there is insufficient evidence on falling or rising poverty in past decades.

Figure 8 Income and wealth inequality in the Netherlands.



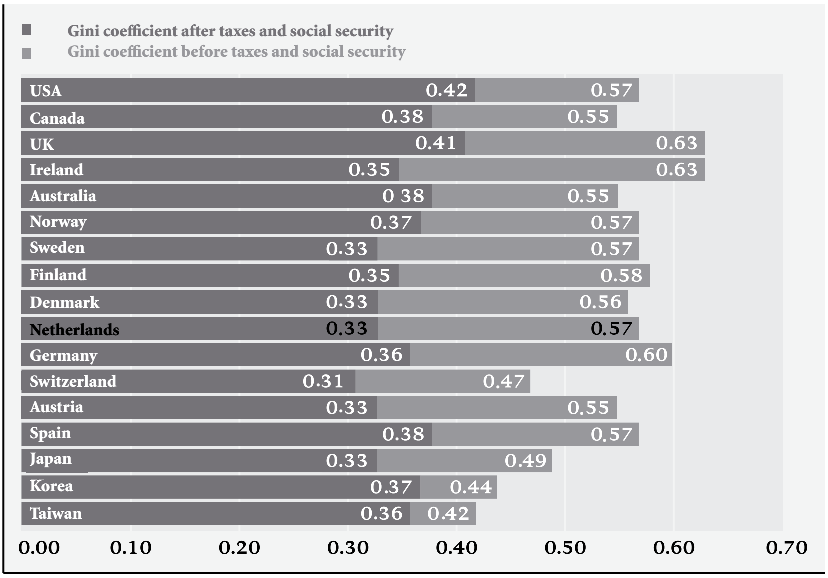
Source: Atkinson & Morelli 2014, p. 40

Looking at the primary income distribution (Figure 8), we can see a Gini coefficient of 0.57 for the Netherlands, which is similar to that for many other European countries. Redistribution (through progressive taxes, benefits, surcharges, and grants) ensures that the secondary income distribution (disposable incomes) is, with a coefficient of 0.33, much more uniform – similar to the Scandinavian countries.

The Gini coefficient has been stable in the Netherlands for several decades. By contrast, Salverda (2014) finds that income inequality has risen sharply. According to Salverda, the Gini coefficient is an inadequate measure because it does not provide any understanding of the distribution between the upper and lower ends. Salverda analyses the deciles of gross incomes over the period 1977-2011 and, based on this, concludes that the income distribution shows "massive and virtually permanent stagnation" at the bottom and a "strong steady rise for a limited group" (Salverda 2014, p. 40). In Salverda's view, this increase in inequality applies to both gross and disposable incomes.
On the internet forum for the economists MeJudice, Caminada et al. (2015)

conclude that, based on their data, there is “no trace” of growing inequality in the income distribution. “The share of top incomes in total gross income remained stable in the Netherlands over the period 1990-2012. That also holds for the share that the top 0.1%, 1%, and 5% pay in income tax. The top 10%’s share of the total tax burden has risen significantly, to 33.2% in 2012. The image of the rich getting steadily richer therefore does not hold water so far as the Dutch income distribution is concerned.” In a response to this, Salverda (2015) asserts that the income distribution gives a limited idea of inequality: “What really determines whether you are rich or not [is] wealth.” And the picture for wealth distribution is completely different from that for income distribution.

Figure 9 Gross and net income inequality in various countries (beginning to mid-2000).



Source: Kremer et al. 2014, p.19.

Wealth distribution

Wealth consists of home ownership, savings, shares, businesses, goods, and so on. As in other countries, wealth in the Netherlands is much more unevenly distributed than income, as the Gini coefficient of 0.8 shows (Bavel 2014).

This figure may even be an underestimate because very large fortunes are in some cases spread worldwide and thus hidden from view. Whereas the bottom 60% of the population owns 10% of wealth, the top 10% owns more than half of national wealth (Bavel 2014). Within this last group, the distribution is also very lopsided. According to the Statistics Netherlands’ data on which Bavel bases his study, the richest 2% of the population owns more than 30% of the wealth. The picture becomes even more clear-cut if we look at sources that try to estimate the wealth of the very richest directly: according to Quote 500, in 2012 the 500 richest households (< 0.01% of the population) owned more than 10% of the wealth (Bavel 2014).

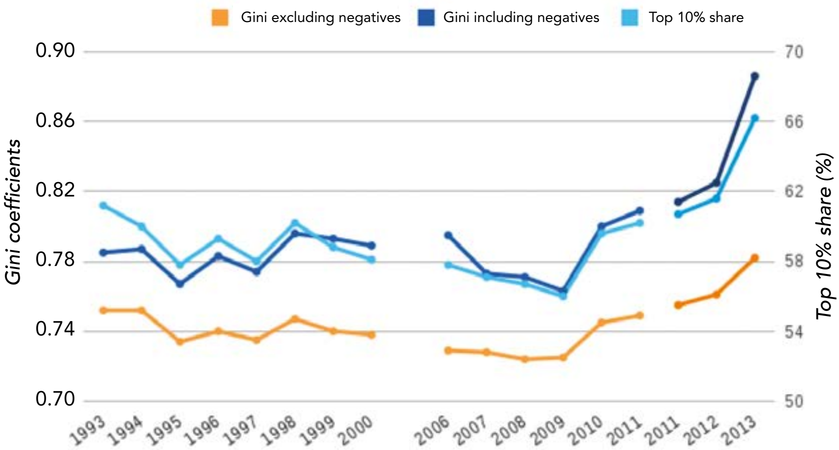
Wealth inequality is greater in the Netherlands than in most other European countries and, according to Salverda (2015), with a Gini coefficient of 0.89, even higher than in the United States. Over time, the Netherlands shows a fall in wealth inequality until the beginning of the 1980s, and high, but relatively steady inequality in the subsequent period (Bavel 2014).

Bavel cites four causes for the unequal wealth distribution in the Netherlands: 1) the Dutch welfare state, which has taken away the need for citizens to build up financial buffers, 2) sharply rising house prices in the last thirty years and a favourable business climate, 3) the increased mobility of capital, and 4) the drop in taxation on assets and capital gains.

The publication by Piketty (2014) has recently put wealth distribution in the Netherlands under the spotlight. Particularly his central proposition that in the last few decades wealth has grown faster than the economy (production and wages) in many countries is attracting considerable attention. Piketty does not provide any data on the Netherlands, and Bavel, too, indicates that the picture since 1980 is not very reliable owing to missing data and changing methods of recording them. Schaaijk (2015) and Coenen (2015) attempt to fill this gap by presenting more up-to-date information on the Dutch situation. According to Coenen (2015, p. 120), the 'precise evolution of wealth inequality […] for the Netherlands in recent decades is virtually unknown.' Based on the various series of data, it can, in Coenen's view, be stated that wealth inequality was falling until 1978, and that a robust trend of growing wealth inequality is also perceptible until 1989. Since then, the picture has been unclear, although Coenen concludes that it is unlikely that the share of wealth of the top 1% has decreased since 1990. Schaaijk (2015) presents data on the capital coefficient (the ratio between capital and national income) to test Piketty's proposition for the Netherlands, and finds that the picture for the Netherlands, with initially downward (until the mid-1970s), subsequently stable (until 2009), and lastly modestly upward wealth inequality, differs from the picture that Piketty outlines for other countries.

According to Bavel (2014), it is likely that these figures do not tell the whole story: the dynamics lie mainly in the poorest households (rising debts) and the richest households (sharply rising wealth), so that growing inequality in the wealth distribution is more likely than a stable evolution. Lastly, Salverda (2015) also stresses that the wealth difference (and the top share of it) is great in the Netherlands and has risen sharply in recent years: "In 2013, the share of all wealth accounted for by the top 10% of wealth is 66%, by far the highest level ever achieved with the available figures. Two thirds of all wealth is in the hands of a tenth of all households." The Gini coefficient as presented by Salverda is so high partly because negative assets (mortgages 'under water') are also included in total wealth (Figure 10).

Figure 10 Wealth distribution: top 10% share and Gini coefficient of net wealth distribution, 1993-2000 and 2006-2013.[72]



Source: Salverda 2015.

Regional aspects of prosperity distribution
Regional differences in income and wealth distribution are growing.[73] Within the Netherlands we can see sharp demographic and economic growth in the Randstad conurbation, and population ageing and contraction in the peripheral parts of the Netherlands, which is set to continue in the coming decades (PBL 2013). Kasper et al. (2015) identify two groups of provinces: firstly, there are peripheral, ageing provinces which young people are leaving, and where income inequality is decreasing and wealth inequality is growing. Secondly, there are primarily the Randstad provinces with a relatively young population, where income and wealth inequality is increasing (Kasper et al. 2015). Globally, we can see a new form of technology-driven accumulation, which has now become known in Germany (as a result of debate about the Uber taxi service) as 'platform capitalism' (Lobo 2014; see also Chapter 2). The fact that Uber has grown within a few years to a stock market value of 41 billion euros (MacMillan, Schechner & Fleisner 2014) and that Apple has now become the biggest

72 Figures for 2013 are provisional, a switch was made to a different method of measurement in 2006.
73 All this nevertheless depends on the level of analysis: globally, differences are shrinking owing to the strong economic growth and the growth of the middle class in countries such as China, India and Brazil (Milanovic 2012).

company in the world with a value of more than 700 billion euros (NASDAQ 2015) illustrate this; this represents huge growth compared with 2013, when the company was worth $170 billion.

Prosperity distribution between generations

It seems as if generations and origin are becoming more important again in the distribution of prosperity. The picture of a reasonably prosperous older generation who have known the luxury of permanent jobs and good pensions is increasingly contrasting with insecurity about work, the accrual of pensions, and scope for obtaining mortgages. The SCP report *Verschil in Nederland* (Vrooman, Gijsberts & Boelhouwer 2014) also emphasizes that there is no *age war*, because the groups are too heterogeneous for that. Origin seems to be becoming more important again in the chances that people get. High-skilled people are increasingly intermarrying, and the distance between social groups is growing (Bovens et al. 2014). Internationally, there are concerns notably in the United States about growing and persistent inequality. Stiglitz (2012) paints a picture of a society that is becoming increasingly polarized because the implicit social contract between the top and the rest ("We will provide you jobs and prosperity, and you will let us walk away with the bonuses") has broken down (Stiglitz 2012, p. 12). A high degree of inequality is, in Stiglitz's view, also very detrimental for economic growth. Putnam (2015) paints a gloomy picture of growing segregation in the United States in which principally the younger generation are feeling the pain of forty years of "unprecedented growth in inequality in America" (Putnam 2015, p. 36). This segregation not only runs along lines of education and work, but also leads to the undermining of traditional family structures at the bottom of society. The emergence of a 'hereditary meritocracy' is said to be occurring, in which social mobility is declining, and origin and family capital are becoming more important for education and work: "As computing power has increased and clerical jobs have been automated, the distance between the shop floor and executive positions has increased. It was never common for people to start at the bottom and work their way to the top. Now it is close to impossible" (*The Economist* 2015a). Stiglitz (2012) subscribes to the view that technology is important in the growing polarization on the labour market, but emphasizes that this continuation of growing inequality is not unavoidable: investment in education, but also bank regulation, taxation, strengthening the position of the trade unions, and promoting a green economy are important measures that can reverse the growing inequality.

Prosperity: the quality of labour

Vrooman, Gijsberts & Boelhouwer (2014, p. 323) state that in the Netherlands there is "(…) a certain fixation on financial differences [consistent with and] that forms part of a national tradition." And they refer to "(…) the paradox that the debate about social differences is often fiercest in countries with relatively little inequality." They further assert that it is important to consider matters more broadly than just looking at financial differences. On issues of the distribution of prosperity, it is therefore important not only to look at outcomes in terms of the distribution of income and wealth, but also to examine how the quality of labour is distributed between different groups on the labour market and what future prospects are like in terms of security of jobs and income.

In the debate about job quality, a distinction has since Piore (1972) been made between the 'primary' and 'secondary' labour market. The primary labour market concerns in general permanent jobs requiring formal education and paying high salaries. The secondary labour market covers all manner of part-time, often temporary work at the lower end of the labour market, generally in the service sector, carried out by the low-skilled or students. Although it is often assumed that, under the pressure of globalization and flexibilization, the characteristics of secondary labour markets are increasingly starting to apply in primary labour markets ('democratization of labour market risk'), Dekker & Veen (2015) cite eleven countries in Europe where the differences between the 'insiders' with the good jobs and the 'outsiders' with the 'crumby jobs' are still substantial.

In the Netherlands, most people still work in paid permanent employment, but that picture seems to be changing quickly. Of workers above the age of 25, nearly 70% are in permanent employment with a fixed number of hours, whereas the corresponding figure for young people under the age of 25 is only one third (see Figure 11). Anticipating changes in dismissal law as of July 2015, businesses are also adapting their policy.[74]

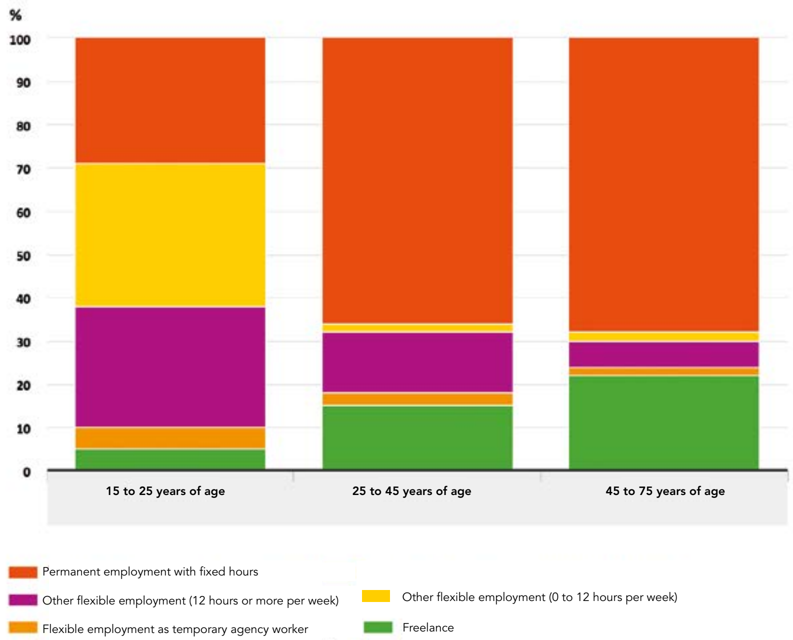
Two major changes are the increase in flexible work contracts (flex work) and the increase in the number of self-employed people without employees (freelancers). Flex work entails various types of arrangements such as: part-time work, agency work, temporary contracts, payrolling (transfer of legal employment to a specialist firm), and zero-hours contracts. The groups of workers who, whether or not forcibly, opt for these variants are mainly young people, elderly people, women, and non-western, foreign-born migrants. Between 1996 and 2010, the proportion of self-employed people without employees in the active population of the Netherlands rose from 6.2% to 9.8% (11.6% for men and 7.9% for women in 2010) (Bosch et al. 2012). According to the *Enquête Beroepsbevolking* (EBB) (Working Population Survey), at the end of 2014 there were 1.1 million self-employed people; the number of self-employed people

74 'Dutch insurance company Nationale-Nederlanden turning down temporary agency workers' was the headline on the Dutch daily newspaper *Volkskrant* on 22 April 2015. On 22 April 2015 the employee insurance company UWV prevented building company Heijmans' planned dismissal of 158 permanent staff (and possible replacement by flex workers) (*Het Financieele Dagblad*, 22 April 2015).

without employees was over 800,000 (Statistics Netherlands 2014b).[75] The expectation of CPB (2014) is that the number of freelancers will, if policy remains unchanged, increase in the short term to more than one million.

The self-employed seem to be more a more diverse group than flex workers in paid employment. High-skilled self-employed people are often 'happy workers': their quality of work is high, and they score above-average on work satisfaction measures (SCP 2014). This is much less the case for the lower-skilled and those forced into self-employment.[76] The work-home balance is often a problem for the self-employed, as is insecurity about the future, the sometimes small number of clients, and above all the high level of under-insurance for unemployment, incapacity for work, and pension accrual (CPB 2014b). The question is what the increase in the number of flex workers and self-employed people means for existing arrangements on the housing market (access to mortgages), the social system, and pensions.

Figure 11 Work status by age (2014).



Source: Statistics Netherlands 2015.

75 The difference consists of self-employed people with employees, co-working family members, etc.
76 Interview with Fabian Dekker.

Another look at differences in the Netherlands

The Netherlands Institute for Social Research (SCP) (Vrooman, Gijsberts & Boelhouwer 2014) adopts a broader concept of differences between population groups, and distinguishes not only 'economic capital' (including income, wealth and education) but also 'personal capital' (physical, mental and aesthetic), 'cultural capital' (including language and communication), and 'social capital' (relations with other people). Based on the sum of these different forms of capital ('total capital') and statistical analysis, six separate social classes are identifiable (from high to low):

- the established top stratum (15% of the population)
- the younger opportunity-rich (13%)
- the working middle group (27%)
- the comfortably retired (17%)
- the insecure workers (14%)
- the precariat (15%)

The established top stratum and the precariat (a group which remains across the board) can be regarded as social classes because they always adopt the same position on all capital forms and there are 'confirmatory factors': strong group identification and social segregation are examples. The other four classes are seen as 'social segments', who adopt changing positions on the various capital ladders. These four segments also have less of an identity of their own and do not exhibit any confirmation of the group differences. There is thus not a simple two-way split, but four groups do markedly better than the insecure workers and the precariat. The SCP concludes that the overall picture shows a subdued two-way split between six population groups, with two social classes at the ends, and four recognizable social segments in between.

6.3 The role of technology in the distribution of prosperity: winner takes all?

Technology may in various ways lead to more or less inequality in the distribution of prosperity and well-being. First of all, technology forms the basis for new products and services that can be highly profitable. Furthermore, technology may lead to unemployment, though also to the creation of new employment. Nearly always, this entails different jobs, and usually fewer jobs. Furthermore, technology may lead to growing differences between workers (Autor et al. 2003).

Technological development exerts different effects on different occupations and types of jobs. We have seen how, in the industrial revolution, highly qualified artisans became superfluous when low-skilled cheap workers were deployed in the textile industry (see also Chapter 2). Currently, the situation is rather the other way round. Brynjolfsson & McAfee (2011, p. 73) quote the venture capitalist Marc Andreesen: "The spread of computers and the internet will put jobs in two categories: people who tell computers what to do, and people who are told by computers what to do." Automation and IT are thus favourable for high-skilled individuals (this is because IT raises their productivity and offers new opportunities), relatively neutral for low-skilled people who perform location-bound work, and is primarily bad for middle-class jobs in both industry and the service sector (see also Chapter 5). An interesting study in this connection is that by Akerman et al. (2015). That study shows that the roll out of broadband internet raises production and wages in Norwegian companies. But at second glance it emerges that it is chiefly the wages of the high-skilled that increase (because they benefit more from fast internet speeds in a job in which they have to take decisions based on complex information), whereas those of low-skilled workers decrease (their routine work is easier to automate)..77 In any event, new technology, principally in combination with offshoring, provides an important explanation for growing inequality and the fact that wages are under pressure: "(…) at the same time that labour-saving technological change has reduced the demand for many of the 'good' middle class blue-collar jobs, globalization has created a global market place, putting the same workers in direct competition with comparable workers abroad. Both factors depress wage" (Stiglitz 2012, p. 68).

As Chapter 2 clearly showed, new technology, including information technology, may come to underpin the 'sharing economy'. This involves access rather than ownership, and the sharing of things like cars, accommodation, and tools. But digital services are also characterized by network effects and the virtual absence of marginal costs (Rifkin 2014). These characteristics mean that services become more valuable (both for the user and of course for the provider) as the number of participants grows. As a result, new providers of services can become very successful very quickly (first mover advantage) and develop into new monopolies on the basis of new platforms (Kreijveld et al. 2014). The extreme global concentration of fortunes in, notably, Silicon Valley is an example of this. Very limited regulations mean that these new monopolists (the aforementioned "silicon sultans and robber barons" according to *The Economist*) are given free rein.

6.4 Policy options

IT and automation have mainly had an adverse impact on middle-class jobs, and in future the widespread use of robots will reinforce this. There is thus a real chance that inequality will increase. What can we do to ensure the broadest possible sharing of the benefits of digitization? In this context, the EU refers (notably in relation to the Horizon2020 research programme) to "inclusive

77 In addition, lower-skilled workers may ultimately also benefit from the additional spending on the part of better-earning higher-skilled workers.

societies", in which the reduction of social exclusion and inequality are key (EC 2013). On the other hand, how do we limit the adverse effects of the digitization revolution as far as possible?

This section outlines several policy options, in each case in relation to IT and the market, notably the labour market. Further research is needed to come up with concrete policy recommendations. This section does not address generic policy measures that determine the distribution of income and wealth, such as fiscal policy (tax-free sums, tax credits, negative income tax, progressive taxes versus flat tax, and basic income). Measures relating to wealth (capital gains tax, death duties, and inheritance tax) are disregarded here because they relate to many things beyond IT and the labour market.[78]

Digital divide

The future is digital, and so it is of the utmost importance that many more people can earn a living in the digital economy. In the past, the concept of a digital divide mainly revolved around access to IT and media. Since the Nether- lands is a country with very high levels of internet adoption, the idea is supposedly that a digital divide should be a thing of the past in the Netherlands: "Anxiety about a digital divide proved over the years, in the Netherlands, to be completely unfounded. After all, most Dutch people now have access to the internet" (Bovens et al. 2014, p. 240). Nevertheless, access to the internet is not sufficient on its own, and the emphasis is increasingly on making effective use of IT and on producing goods and services, and thereby being able to make a living (from programming, 3D printing, and so on) (see also Chapter 5). In this regard, the European Commission (2014) refers in its Digital Agenda to the fact that 39% of European workers have inadequate digital skills (e-skills). There is also a growing shortage of IT professionals, which will run to 900,000 in the EU by 2020. European policy therefore advocates much heavier investment in the knowledge and skills needed for the digital age. Europe is tackling this with, for example, the *eSkills for Jobs* initiative, which is also being rolled out in the Netherlands.[79] The development of e-skills in all strata of the population, in education and among workers in enterprises, and in particular at the bottom of the labour market, is needed to get a process of knowledge circulation going (WRR 2013).

Inclusive technology and innovation

Current technology is principally complementary, and therefore favourable, to the position of high-skilled individuals. Technology and automation make it difficult for more and more people (particularly people with mild disabilities) to participate in society (Woittiez et al. 2014). Things such as digital banking,

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78 The media analysis (see Annex 6) reveals that aspects such as basic income and other generic arrangements, specifically fiscal ones, are indeed, albeit not exclusively, linked to IT and the impact on the labour market; articles examining the impact of robotization on the labour market therefore cite these arrangements as such as policy options.

79 http://eskills4jobs.ec.europa.eu/

public transport chip cards, and online tax returns prove too complicated for them. This is often because it is the provider's and not the user's interest that is the main focus – the public transport chip card is a case in point.[80] Technology that supports the low-skilled instead of making them redundant is therefore very welcome. Solutions are now being developed for people with disabilities under the motto of 'inclusive technology', and the UK charity Nesta has established an *Inclusive Technology Prize*.[81] In relation to cooperation on development, the concept of inclusive innovation is now well established: it concerns the development of knowledge and innovation for the benefit of, principally, poor population groups (Mohnen & Stare 2013). A focus on empowerment, and, putting the user and ease of use at the centre of things, are essential. Research and technology development play a part here. The choices made and the priorities set based on publically funded research may significantly speed up the development of inclusive technology and innovation.

Regulation of new platforms

Ten years ago, IT was supposed to lead to a process of 'disintermediation': making intermediaries unnecessary. And that has indeed happened, as we can see from the bankruptcies of travel agencies (*The Economist* 2014). Nevertheless, network effects are quickly leading to digital providers developing into new 'middlemen', new monopolies that charge a substantial percentage (20-30%) of all transactions (App store, Uber, Booking.com). Regulation of these new monopolies is practically non-existent at present, partly because they are new and partly because they design their marketing around the 'sharing economy', which often exudes positive connotations. A debate has now started within Europe, and the European Commission argues that regulation is needed to promote competition and prevent the creation of monopolies. In this context, the Commission is launching a study to investigate abuse of market power by Google (EC 2015). Services such as UberPop are currently the subject of judicial investigation in a number of countries.

At the same time, the spectacular success of the new platforms shows that this is a radically new business model offering brand new, universal innovation dynamics as a result of full digitization, network effects, and the virtual absence of marginal costs (Kreijveld et al. 2014; Rifkin 2014). This also offers opportunities for growth and innovation; it is therefore important to use the strength of platforms and curb their power (for concrete policy recommendations, see Kreijveld et al. 2014).

80 Illustrating this, in 2014 the *Consumentenbond* (Dutch Consumer Association) received 2,400 complaints about the card, and a special public transport pass for tourists is now under consideration, to eliminate problems. See http://www.consumentenbond.nl/actueel/nieuws/2014/nog-veel-te-veel-klachten-over-reizen-met-ov-chipkaart/ and https://fd.nl/economie-politiek/1098833/speciale-ov-kaart-voor-toeristen-moet-belemmeringen-wegnemen.

81 http://www.nesta.org.uk/project/inclusive-technology-prize

(Digital) start-ups

New digital activity is a source of economic growth and high-quality employment, with start-ups and young businesses playing a key part (OECD 2014b). The desirability of much stronger support for digital start-ups is now recognized, as witnessed by the Startup Delta initiative, which has Neelie Kroes as its figurehead.[82] Start-ups need specific support initiatives because, as companies that are not profit-making, or at least not yet, they do not benefit from the various fiscal arrangements available under innovation policy, such as R&D deductions and the Innovation Box, which reduce tax.

In the view of some people, the promotion of small-scale initiatives (including by provincial and local authorities) also deserves closer attention. Services such as wehelpen.nl (a kind of marketplace that brings together demand and supply for all kinds of help) and Carenzorgt.nl (for all manner of types of care) are good examples. A role may also exist for local authorities with regard to the online neighbourhood help platforms that are emerging (Busch 2014).

Labour market policy

Digitization helps underpin a much more flexible labour market with a sharp increase in the proportion of flex workers and self-employed people without employees. Current policy is making slow progress in giving this growing group more security. In view of the growing inequality in terms of contract types, some are wondering whether much more radical innovations are needed. For example, the OECD has conducted research on the single labour contract. Under this scheme, everyone would have the same contract, a sort of zero-hours contract, and everyone would accrue rights, namely social rights and pension rights, from the first working day (OECD 2013b). Whether such a contract provides a solution depends very much on the existing institutions and structures in an economy, and how, for example, pensions are regulated.[83]

Beyond labour market policy, pleas are being made, as for example by Freeman (2014), to give workers a share in businesses that invest in technology and robots and thereby make labour redundant. Freeman thinks that governments will redistribute inadequately via taxes, and therefore sees workers' ownership of capital as an alternative.

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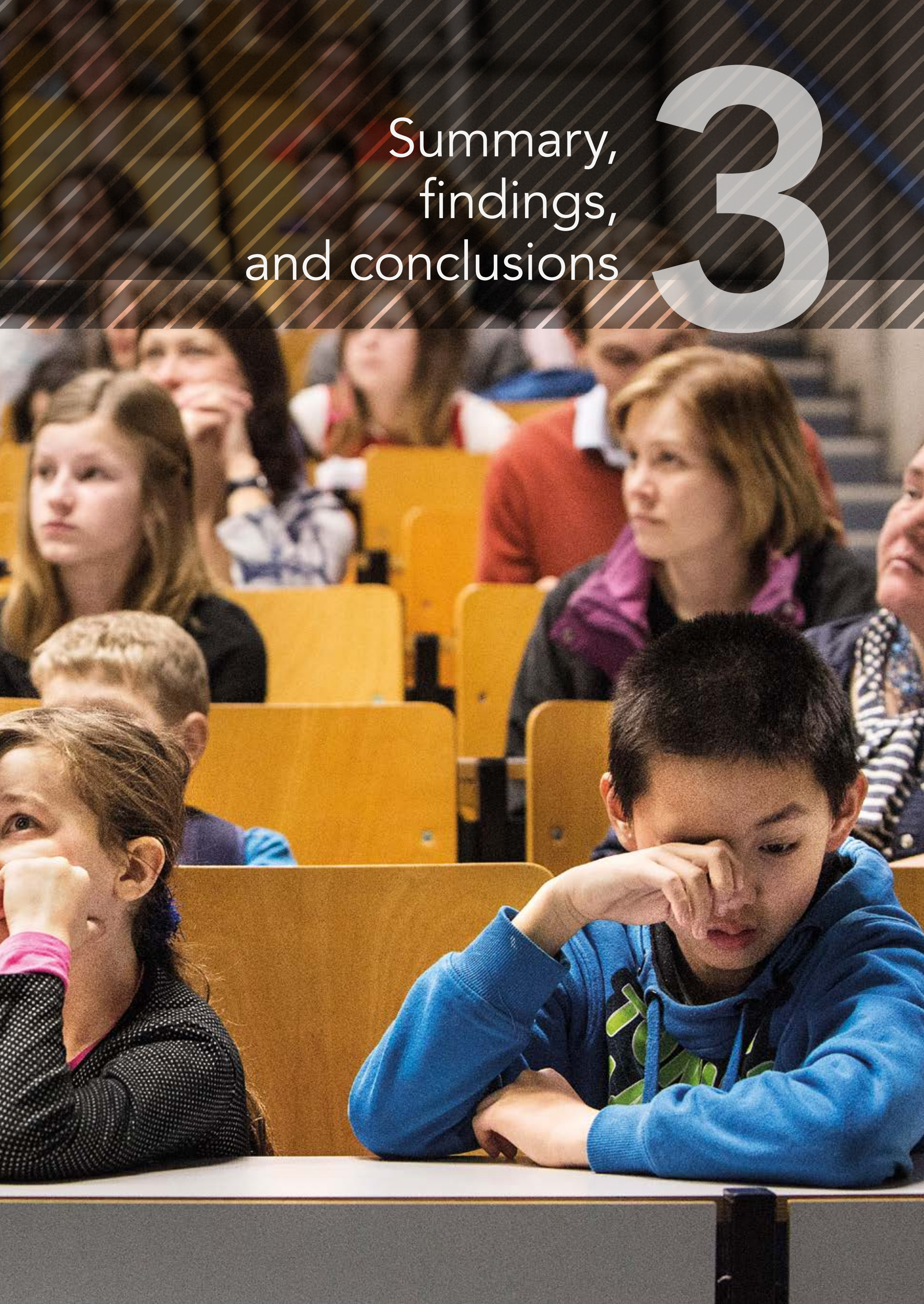
82 http://www.startupdelta.org/

83 Interview with Bas ter Weel.

3 Summary, findings, and conclusions



7 The robot society as a mobilizing perspective

Rinie van Est, Linda Kool, and Frans Brom

> *"Technical developments and thus also the chip have to be scrutinized for their consequences on the environment, people's way of life, employment, and quality of work. (…) The introduction of technological developments, in other words including the chip, should always be scrutinized in the light of the conditions that society formulates."*
> – Den Uyl (1979)

7.1 Introduction

On behalf of the Standing Committee for Social Affairs and Employment, the Rathenau Instituut has conducted research on the latest scientific findings concerning the effect of technological developments on employment. The Standing Committee has formulated the following central question: what are the current[84] scientific findings for the impact of technological developments on employment?[85] The associated subquestions concern the availability of relevant and current scientific knowledge regarding the following aspects:

1. The impact of technological developments (mechanization, automation, et cetera) on employment in the past.
2. The potential impact of technological developments on future employment.
3. Scope for responding, through policy, to future effects on employment, for example by means of education.

This study maps out current scientific knowledge concerning the complex relationship between technological developments and labour. Where is there scientific consensus, where is there dissension, and where are there gaps in our knowledge? Can science provide a shared fund of knowledge to underpin the societal and political debate?

We have structured our approach to answering these questions in accordance with two main themes: 1) technological development in a historical and social perspective (long-term), and 2) the relationship between technology and employment (the recent past and forecasts for the future). In section 7.2, we

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84 Over the last ten years.

85 Parliamentary Papers II 2014/205, 29 544, number 583. Letter from the Praesidium concerning labour market policy. .

summarize the main findings of the chapters for the past (the long-term perspective). Section 7.3 sets out the takeaway message from the recent past. Section 7.4 describes the forecasts for the future. Based on this, in section 7.5 we arrive at three overall approaches for future policy. As stated in the introduction, these options call for further reflection and research to come up with concrete policy recommendations in relation to IT and employment.

7.2 The past: long-term perspective

Second machine age and the robot internet
Historians of technology often mention three industrial revolutions: the introduction of steam, electricity, and information technology (IT). The distinction between the first and second machine age is also important in the debate about technology and labour, as Chapter 2 shows. The first machine age covers the first and second industrial revolution. It chiefly consisted of machines that provide muscle power. The third industrial revolution – the IT revolution – ushers in the second machine age, in which machines also supply thinking power.

In thinking about the relationship between technology and employment, we should therefore consider the technical characteristics of the current IT revolution. This entails not only physical robots but also technologies such as 'softbots', artificial intelligence, sensor networks, and data analytics. It involves the advent of the Internet of Robotic Things, or the robot internet. In this way, the internet is being as it were expanded with 'senses' (sensors) and 'hands and feet' (actuators), and, as a result of machine learning and artificial intelligence, the internet is also becoming 'smart'. The management and analysis of large volumes of data is of key importance in this regard. Machines from the first and second machine age provide scope for taking over physical work and cognitive work respectively from humans. Whether or not such scope can be utilized depends, however, on how production and labour are organized.

From mechanical to digital Taylorism
The continuous search for new forms of organization is usually driven by rationalization, or the quest for greater efficiency and control, including control over the worker (see Chapter 2). In the first machine age, starting in 1910 the traditional factory was redesigned into 'a big efficient machine' on the basis of (mechanical) *Taylorism*. This was done by splitting work processes into simple tasks, thus allowing certain physical tasks to be mechanized and later automated. In the second machine age, and through the advent of IT, the services sector since 1980 came under the influence of digital Taylorism. Where mechanical *Taylorism* allows the automation of physical work, digital Taylorism allows the automation of cognitive work. As a result, it has also become possible to outsource, offshore, automate not only physical but also cognitive tasks. Thinking about new and more efficient ways of organizing things has received fresh impetus since 1995, owing to the arrival of the internet. The

internet boosts the internationalization, flexibilization, and platformization of labour. We can see the advent of the virtual network organization which seeks to optimize on-demand access to paid and unpaid work. This body of ideas underpins, for example, the way in which Uber uses drivers.

Lessons from the Netherlands' past

In the past, the Netherlands has been able to benefit from the three industrial revolutions described. However, that required foresight and an active adaptation process that often did not take place without setbacks (see Chapter 3). The government has always played an important part in the introduction of new technologies by creating the right conditions. Firstly, this entails fostering innovation by investing in physical and knowledge infrastructure (such as knowledge institutions and training). The construction of a good transport system (canals, railways, and paved roads) in the first half of the nineteenth century paved the way for the use of coal and steam engines, and thus the growth of, for example, the textile industry in Twente (in the eastern part of the Netherlands) in the second half of the nineteenth century. Extending the electricity grid to the entire Netherlands meant that, in particular, small and medium-sized enterprises could benefit from the potential of the second industrial revolution. Secondly, the government played a key role in regulating new practices, preventing excesses, and distributing prosperity. Examples include social legislation, such as Van Houten's Labour Act of 1874, the first Compulsory Education Act of 1901, and the Social Assistance Act enacted in the 1960s.

7.3 Recent past

The debate about the relationship between technology and employment is characterized by two opposing visions. According to one vision, innovation leads to economic growth, jobs growth, and an acceptable distribution of prosperity. In this way, technological innovation leads to greater labour productivity and cheaper products, which in turn bring about higher consumption, and thus market growth and more jobs and prosperity. According to the alternate vision, increasing labour productivity through innovation (via labour-saving technology) conversely leads to less work, and thereby to lower purchasing power and consumption, and thus to shrinking profits and markets, and declining prosperity. The assumptions behind the two visions outlined raise the following secondary questions: within science, what is known about the relationship between the IT revolution and productivity, between IT and the loss and creation of jobs, and about how IT influences our prosperity? In this section we summarize the findings from the chapters dealing with these secondary questions. On each secondary question, we set out on what points there is, broadly speaking, a scientific consensus.[86]

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86 This does not mean that there is no debate about measurement methods, available data, or the results for these issues.

Impact of IT on (labour) productivity

The relationship between economic growth and productivity growth, on the one hand, and the role of IT, on the other, is complex, with many factors influencing it (Chapter 4). The IT revolution brought about great changes in the production and labour process, although it was initially unclear whether and where those investments (particularly in the services sector) showed up in the productivity figures. With a growing focus within science on measuring the contribution of IT to productivity and productivity growth, it has become clear that IT has in the past twenty years made an important contribution to productivity growth.

With regard to automation and robotization and their impact on jobs and economic growth, there has traditionally been a consensus among economists that technological growth in the very short term comes at the expense of jobs, but that this provides new jobs relatively swiftly, within one or two years. This occurs via 'second-order effects' in which savings achieved by productivity growth flow back into the economy. This consensus has started crumbling since 2010, among not only criticasters such as Brynjolfsson & McAfee (2014) but also well-known economists such as Krugman (2014) and Summers (2014). This crumbling consensus is based not only on facts – scientific observations concerning employment creation in the short, medium and longer term – but also on changing perspectives on the underlying economic dynamics (see for example various 'diagnoses' of current economic problems by Gordon (2012), Brynjolfsson & McAfee (2014), Cowan (2010), Krugman (2014), Summers (2014), and Rifkin (2014) (see Chapter 4 and section 7.4).

IT and job polarization

Although many factors, including the evolution of the working population, influence the labour market, the impact of automation since the 1980s is evident in the composition of the labour market. Automation has led to job polarization, as Chapter 5 has clearly shown. Demand for medium-skilled work is falling, whereas demand for, in particular, high-and low-skilled work is growing. In previous technological revolutions, it was mainly low-skilled, physical work that mechanization and automation affected. Computers are now taking over routine cognitive work such as administrative work, the performance of calculations, accounting, the monitoring of processes, or the assessment of products. This is also a consequence of digital Taylorism: the rethinking of work processes and being able to split work into subtasks amenable to outsourcing, offshoring, or automation. Likewise, offshoring – which IT has in turn made possible – therefore plays a part in job polarization. Offshoring can be seen as a first step towards the codification and automation of tasks. If you can codify work (capture it in rules, such as a telemarketer's script in a call centre), you can readily relocate and automate it. It is now becoming clear that neither high-skilled nor low-skilled work is 'immune' to job polarization: automation can affect all levels of education and training.

IT and prosperity
Chapter 6 examined how IT influences our prosperity, or, more specifically, how IT influences our opportunities for acquiring income and wealth. IT ensures changes in our economy in many ways. For example, IT investments may trigger changes in employment and pay, but also bring about lower production costs, and thus cheaper products. In addition, the production capacity that labour-saving IT frees up and the income that IT generates, or some of it, may be deployed in other parts of the economy ('second-order effects', see Chapter 4), thereby allowing a rise in general prosperity.

In many countries, the share of national income accounted for by labour seems to be falling at the expense of the return on capital. Technology plays a role in this: technology allows new investments that not only are profitable but also replace labour with capital, and influence globalization (growing competition with low-wage countries). Furthermore, the waning power of trade unions and the increasing liberalization of the labour market play a part. Although labour's share of national income is relatively high (around 80%) in the Netherlands compared with other countries, the share accounted for by labour is also falling in the Netherlands.[87]

The evolution of the income and wealth distribution in the Netherlands is a subject of debate. Although the Gini coefficient – an important measure of income distribution – has been stable for the Netherlands for several decades, it does not provide any understanding of the distribution between the top and bottom of the population, and it may be precisely there that dynamics are greater. In the Netherlands, as in other countries, wealth is much more unequally distributed than incomes (Bavel 2014), but changing methods for recording information lead to missing and unreliable data on the Netherlands. Here, too, there are suspicions that the dynamics lie mainly in the poorest (rising debts) and the richest (growing wealth) households.

Worldwide, we can see a new form of technology-driven accumulation, which has now become known in Germany (as a result of debate about the Uber taxi service) as 'platform capitalism' (Lobo 2014).

Besides this material inequality, the impact of IT on job security is important. The differences between permanent jobs on high or higher salaries and temporary jobs on low or lower pay are persistent (Dekker & Veen 2015). In the Netherlands, most people work in paid employment, but the number of workers on flexible contracts and the number of self-employed people without employees is rising. These groups of flex workers enjoy less protection than workers on fixed contracts, which is prompting a debate about possible ways

87 Although it matters which period is examined (see Chapter 6).

of reducing the differences in protection between both groups (permanent and flexible).

IT thus has differing effects on different occupations and types of job: it is mainly favourable for high-skilled workers, relatively neutral for low-skilled people who perform location-bound work, and exerts pressure principally on middle-class jobs in both industry and the service sector. Coupled with offshoring, IT goes a long way to explaining growing inequality and the pressure that wages are experiencing.

In summary
Although it is difficult to make direct links between technological innovation, productivity growth, jobs growth, and the distribution of prosperity, and the question of whether IT brings about a positive or negative spiral, the various chapters reveal issues on which there is broad consensus within science.[88] In the first machine age (1800-1980), the conventional view has been that technology destroys jobs, but creates new jobs in new sectors relatively quickly. Mechanization and automation chiefly hit low-skilled, physical labour. Technology was skill upgrading, and called for new skills from everyone. Investment in education meant that education always won the 'race between technology and education'. In the second machine age (as from 1980), automation also hits medium-skilled work. IT affects different groups on the labour market in different ways; up to now, higher-skilled people have chiefly benefited from new technology. Inequality consists not only in the distribution of income and wealth, but also in differences in job security; this form of inequality has also been increasing since the second machine age.

7.4 Prognoses for the near future

The second research question is as follows: what are the possible effects of technological developments on future employment? The future is fundamentally unknown because it has yet to be made. It is therefore unsurprising that there are different visions and speculations about the future, which are often contradictory. The future is, after all, 'data-free'. This does not mean that finding out about different visions is pointless. We can see them as interesting (sometimes extreme) scenarios that can help society shape the robot society of the future.

We can draw at least one important lesson from the foregoing chapters: the current international robot debate must not only cover the substitution of labour by technology, as Frey & Osborne do in their study. They predict that

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88 Dat wil niet zeggen dat er geen discussie bestaat over meetmethoden, beschikbare data en de resultaten.

computers or robots may take over nearly half of current jobs in the USA in the next twenty years.[89] To ensure a good debate, it is important to consider not only IT as a means of automating jobs but also the following aspects:

- economic, social, ethical, and legal aspects that are factors in how IT influences labour.
- the role of IT in creating new jobs.
- the way in which IT changes the organization of labour.
- the way in which IT helps determine the distribution of prosperity.

Our concise media analysis concerning robotization and employment shows that most of these themes do not yet figure very much in the public debate (see Annex 6). Around half the articles examined (44 out of 82) concern the question of whether robots will lead to more or fewer jobs.[90] Only 8 of the 82 articles say something about IT and society, and 7 of the 82 say something about the way in which IT is changing the organization of labour.

Social context of IT

The question of the extent to which IT will replace human tasks depends not only on technological scope. All manner of economic, social, ethical and legal aspects may play a crucial part here (Royakkers & Van Est 2015). This encompasses questions such as the following: is technology more profitable than human labour? Logically, this depends on the costs of digital versus human labour. Ethical questions are also important: what use of machines do we find morally acceptable? As a society, we seem to embrace machines that do dirty, heavy, dangerous, or precision work – although this transition is painful for some; the use of 'killer robots' (autonomous, armed drones), but also for example robots in healthcare, seems to be more sensitive.

The government plays a major dual role in innovation. Governments have historically always been important in promoting the development of general purpose technologies, such as the internet and nanotechnology, and the creation of new markets (Mazzucato 2011; see also Chapter 3). In addition, the government plays a key role in the sound integration of new technology in society. To what extent does, for example, regulation make sound postal deliveries via drones possible or impossible? Regulation can hold back certain innovations, but is often needed to provide for innovations that are desirable.

89 Their approach gives roughly the same picture for the Dutch labour market (Deloitte 2014). Their study offers valuable insights into 1) the potential of automation, 2) which sectors and occupations may be affected, and 3) the fact that high-skilled occupations are also vulnerable to automation.

90 It is not illogical that most of these articles deal with this because the articles have been selected on the basis of the subject of robots and labour.

IT as a driver of jobs?

The question of the extent to which IT will help create new jobs is for two reasons more difficult to answer than the question of which jobs are disappearing, on which Frey & Osborne (2013) focus. Firstly, the question that Frey & Osborne ask begins with the existing and known pool of jobs. When considering job creation, this is only partly the case. On the one hand, job creation can arise from the expansion of existing jobs (for example, in healthcare) or from companies bringing back existing activities from other countries (reshoring).[91] On the other hand, job creation entails new jobs in new sectors that do not yet exist (or are just arising) and on which insights are still inadequate.

Secondly, job creation is closely connected with complex macroeconomic dynamics, including with regard to productivity growth and the distribution of prosperity (see also section 7.3 and Chapter 4). As indicated above, consensus about the finding that, although technology destroys jobs, it creates new jobs within one or two years via second-order effects, has been crumbling since 2010. Various economists (see, for example, Miller & Atkinson 2013) assume that this historical dynamic still holds. Others have concerns about the extent to which jobs growth (from various conceptions of the economy) will materialize. For instance, Summers (2014) refers to the failure of consumer demand to appear. If this second-order effect fails to materialize this time, that will put pressure on jobs growth and also technological innovation. Gordon (2012, 2014) highlights the supply side of the economy and cites various structural headwinds, such as demographic developments (population ageing), increasing income inequality, globalization, the evolution of educational levels, environmental burdens, and debt burdens. Brynjolfsson & McAfee (2014) also see the creation of new jobs as a sore point. In particular, they wonder whether jobs growth can keep up with the loss of jobs from automation.

In addition, authors cite the exponential growth of technology. This yields numerous spectacular, but at the same time speculative future scenarios. Diamandis & Kotler (2012), for example, envisage a future in which everything is in abundance. Rifkin (2014) thinks that the advent of the Internet of Things will lead to a zero marginal cost society in which labour and goods will be highly democratized (collaborative commons). Others consider that the speed of technological developments, and the scope for technology to take over human work, are overestimated (see for example Miller & Atkinson 2013).

Independently of the net effect on employment, the question of what future work will entail is important (see Chapter 5). Automation may affect all levels of education, but the expectation is that, in the coming years, it will still be very

91 The direct effect of reshoring on employment may be small because this entails highly automated processes. The indirect effect of reshoring in the creation of work in adjacent fields, such as R&D, logistics and sales, may be more relevant.

difficult to codify the following tasks into computer language: 1) solving unstructured problems, 2) working with new information, and 3) performing non-routine work (Levy & Murnane 2013). Humans will work together with computers on these tasks, complementing each other as far as possible (an example is a doctor who receives assistance from a software program in making a diagnosis). Various collaborative approaches are conceivable, ranging from an approach in which humans instruct the machine to one where the machine provides an equivalent form of cooperation ('the robot as colleague') (*Bundesministerium für Wirtschaft und Energie* (Federal Ministry for Economic Affairs and Energy) 2014). Moreover, the expectation is that work with a personal component will remain, at least in part (Levy & Murnane 2013; Bainbridge 2015; Blinder 2006).

Impact of IT on the organization of labour
Frey & Osborne (2013) look mainly at how IT automates labour. They examine what operations are codifiable, in other words can be captured in rules. But Chapter 2 shows that IT also influences the organization of labour: reorganizing the production process (or business process) allows the digitization of operations. In short, we can say that IT not only allows the automation of labour but also facilitates the globalization, flexibilization and platformization of labour. It is thus also the organizational principles behind the IT revolution – such as mechanical and digital Taylorism – that enable labour to be organized in a manner allowing the automation of labour via IT.

Impact of IT on prosperity
IT and automation have mainly had an adverse impact on middle-class jobs (job polarization). This effect may in future be reinforced by the growing use of automation and robots, which may increase inequality further. Although high-skilled people are not immune to automation, as mentioned above, automation has a chiefly favourable impact for this group for the time being. [92] An interesting study in this context is that by Akerman et al. (2015). That study shows that the building of the broadband internet raises production and wages in Norwegian companies. But at second glance it emerges that it is chiefly the wages of the high-skilled that increase (because they benefit more from fast internet speeds in jobs in which they have to take decisions based on complex information), whereas those of low-skilled workers decrease (it becomes easier to automate their routine work).[93] Technology thus boosts the productivity of the higher-skilled and offers them new opportunities (see Chapter 6). They also more frequently have generic skills considered important in acquiring a good socioeconomic position (CPB 2014a).

92 This does not mean that low-skilled people can be classed as 'the losers from modernization', in terms of quality of life (work, health, life satisfaction) (Elchardus 2013).

93 In addition, the lower-skilled may ultimately also benefit from the additional spending on the part of better-earning higher-skilled workers.

The emergence of platforms shows that providers of these services can in a short time become very successful and develop into new monopolies (Kreijveld et al. 2014). The extreme worldwide concentration of fortunes in, notably, Silicon Valley is a case in point. Very limited regulation means that these new monopolists – "silicon sultans", according to *The Economist* (2015) – are experiencing very little resistance. Stiglitz (2012) subscribes to the view that technology is important in the growing polarization on the labour market, but emphasizes that this continuation of growing inequality is not unavoidable: investment in education, but also bank regulation, taxation, strengthening the position of the trade unions, and promoting a green economy are measures that Stiglitz cites as being important in being able to reverse the growing inequality. There is also debate about the growing number of flex workers (made possible, among other things, by digitization) and the difference in protection between workers with or without permanent contracts.

In summary: towards a broad perspective on technology and labour
What does the above mean in identifying the possible impact of technological developments on future employment? Our study shows that the influence of IT on labour is multi-layered and is for the most part difficult to predict. In this context, Allenby & Sarewitz (2011) refer to three levels of technological influence. The first level concerns the 'direct' effects of technology: in this case, the disappearance of existing jobs as a result of automation. This effect is the subject of considerable attention in the current debate. The second level concerns the greater 'sociotechnical' system (practices, institutions, social and cultural patterns), encompassing specific methods that help determine the impact of technology. An example is the advent of platforms (such as Airbnb and Uber), which IT has made possible and which save capital and labour. The third level concerns a global, transformative influence, such as the break-through of the internet in the mid-1990s, the lowering of costs of doing business internationally, and the formation of global value chains. Further servitization of the industry is envisaged for the coming years.

IT consequently has a very multi-layered and diverse influence on labour. IT allows the automation of existing jobs, but also influences in a complex manner the way in which labour practices and global value chains take shape. The challenge for policymakers and politicians is to respond in a timely and intelligent way to this whole set of IT-related developments.

7.5 Policy options

In this section we examine subquestion 3 of the brief assigned to the Standing Committee for Social Affairs and Employment: what relevant and current scientific knowledge is available on scope for responding to the future impact on employment by means of policy, for example via education? We discuss three central policy options in which we build on and refer to the insights from the various chapters. These are broad policy *directions* that have not been investigated in terms of their possible effect (impact), for example in the current context, or for the Netherlands. As previously mentioned, further analysis is needed to come up with concrete, more specific policy *recommendations*.

The robot society as an inviting prospect

The current debate within society about IT and employment recalls the 1970s. That was likewise a time of recession and growing worries about job losses as a result of automation, concerns that sparked public debate and further investigation. The Rathenau Committee was established to examine, among other things, the consequences of microelectronics on society.

In retrospect, that period of unrest, debate, and investigation has been crucial in creating awareness of the importance to society of the IT revolution, which had entered a new phase: a transition from the 'large' mainframe computer to the 'small' personal computer. The debate that began with the question of what 'small' computers would mean for labour broadened out to the question of what the computer society should look like. The mobilizing concept of the 'information society' arose in that way. This concept was subsequently deliberately used to "make finances and energy available within all parts of society for the use of computers" (Bogaard et al. 2008, p. 241).

There is a growing feeling that our technological society is again entering a new phase. Over the past decade, we have experienced the rapid rise of the internet and social media. On the one hand, we are experiencing the fantastic new opportunities that the internet offers us, from electronic shopping to music streaming. On the other hand, the idea is dawning that the benefits of IT are certainly not equally shared for everyone. The picture is wide-ranging: digitization often stands in the way of the ability of mildly disabled people to live independently (Woittiez et al. 2014), leads to the automation of many medium-skilled jobs, offers high-skilled people an opportunity of improving their social position, while 'winner-takes-all markets' play a part in the emergence of a new group of extremely rich entrepreneurs. It is unclear what impact these changes will have on various groups, for example in terms of the evolution of purchasing power. We are currently faced in all kinds of ways with new technological possibilities: from artificial intelligence and robots in healthcare to self-driving cars, sensor networks, big data, 3D printing, drones, and so on. This broad development is captured in terms such as the Internet of Things and the Internet of Robotic Things. The big question is now: how do we, as a society, deal with this new phase of the IT revolution?

History offers insights on this question, showing that technology does not simply happen to us, but takes shape in all kinds of practices. Our response to the industrial revolution was the formation of an industrial society made possible by the appropriate technological and knowledge infrastructure, though also by all kinds of social legislation (see Chapter 3). Our response to the advent of the computer was the information society (see above). The response to the advent of robotics and the robot internet may therefore be something like the 'robot society'. The term robot society is pointedly in inverted commas because it is a concept that must be fulfilled; it is, so to speak, a mobilizing perspective. It is important that the Netherlands in the broadest sense – from citizens, politicians, educators, and entrepreneurs to people in manufacturing, the creative industry and the services sector – familiarize themselves with the new technological options and visions in the sphere of IT to enable us to appropriate these options based on our own wishes and concerns. Fashioning a 'robot society' so that it can represent an inviting prospect for all Dutch people calls for an active policy in much of society.

Although the future is unknown, the possible prospects for governmental action that emerge from this report differ in form.[94] In some cases these are well-known approaches, such as investing in education or investing in technology for the benefit of economic growth; in other cases, they will get a new dynamic and a character of their own due to the specific characteristics of the 'robot society': examples include regulation of the monopolies brought about by platforms, or investment in 'inclusive technology' (see below). In the following sections we discuss three central policy options in which we build on and refer to the insights from the various chapters: socially responsible innovation, education, and prosperity.

Socially responsible innovation

The historical perspective (Chapter 3) shows that early investment in physical infrastructure and the construction of adequate knowledge infrastructure are essential to reaping the benefits of new, emerging generic technologies. Every era imposes its own demands. During the first industrial revolution, for example, the Dutch government – despite the poor state of the national public finances – invested heavily with market players in transport infrastructure, such as paved roads, canals, and railways. In the second half of the nineteenth century, this facilitated, for example, the modernization of the textile industry in the town of Twente. The associated knowledge infrastructure also matured, with the launch of engineering courses and the Royal Netherlands Society of Engineers.

94 Brynjolffson & McAfee (2014) indicate that, despite the uncertainty about the future, over the years there have been policy options on which economists agree, and these will continue to be important in the future: 1) investment in education, 2) promotion of entrepreneurship and start-ups, 3) promotion of 'matchmaking' between demand and supply on the labour market, 4) investment in science and technology, 5) investment in infrastructure, and 6) levying taxes 'wisely'. We can also see these overall directions in the options we set out below.

During the second industrial revolution, the development of a reliable electricity grid was crucial. Private operators and municipalities initially played a role in this, followed by provincial and national authorities. During the current information age, computers initially came into use in the 1950s, for example to automate administration at insurance companies. The first professional associations in the field of automation also arose at that time. During the 1970s and 1980s, when the PC came into the picture, the development of knowledge infrastructure entailed such things as setting up computer service centres, new professional associations, and the development of digital skills in the population by promoting home use of computers. The 1990s and the beginning of the new millennium saw the development of fast internet connections.

Embrace the information revolution

Now, too, there is debate about what part the government can play in boosting economic growth via the promotion of technological development (see Chapter 4). Embracing the information revolution seems to be an important key for the future because it boosts productivity growth, even if there is debate about the direction and choice of the investments.[95]

An important issue in the adoption of new technology and innovation concerns the successful introduction and integration of rapidly evolving technologies in social practices. This raises the following questions, which in future will require further investigation: is the Netherlands investing enough in new technology? Where would more investment be desirable? How can start-ups, notably digital ones, be supported?[96] What stands in the way of the changes needed – and what part do our institutions play in this (laws, rules, and application)? Thus, for example, there is debate about the different reactions in the United States and Europe to new services such as Uberpop.[97] How can public investment in technology and innovation contribute sustainably to a prosperous Netherlands? In this context, Chapter 6 cites the development of inclusive technology and innovation (the UK charity Nesta was mentioned, which has instituted the Inclusive Technology Prize).

Smart industry

Internationally, a reappraisal of manufacturing is currently perceptible. Since the 1960s, a lot of labour-intensive and low-technology production capacity has been relocated from the Netherlands to low-wage countries. The thinking behind this was that low-technology assembly work was relatively unremunerative compared with other parts of the value chain, such as research and

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95 Depending on how and from what perspective the problem is diagnosed (see Chapter 4).

96 An example is Startup Delta, with Neelie Kroes as its figurehead. See http://www.startupdelta.org/.

97 Interview with Bart van Ark, see also http://www.nrc.nl/nieuws/2015/04/16/uber-topman-europa-loopt-jaar-achter-op-vs/.

development (R&D), production of high-quality products, branding, design, sales, and marketing. This is called the *smiling curve* (Swedish National Board of Trade 2012). The Netherlands, too, adopted this approach, as is apparent from the example of the textile industry in Tilburg. The Netherlands could also have chosen to keep production here by deploying technology, in other words by shifting from low-skilled to high-technology production. But local government chose to promote other sectors, such as services and recreation. In the dairy sector, by contrast, a choice was made to deploy technology.[98]

In the Netherlands, the Smart Industry Action Agenda (FME et al. 2014) has been launched to get its manufacturing sector ready for the digital future. In this regard, the Netherlands is also seeking to link in with developments taking place in Germany concerning the notion of Industrie 4.0. That discourse is giving off a lot of positive energy, but, according to Pfeiffer[99], is also driven by the anxiety that Germany is losing its global lead on high-technology manufacturing to countries such as China and India, which, as a result of heavy investment in education, now have a lot of high-skilled people.

China is now the biggest exporter of high-tech products (Beltramello et al. 2012), and multinationals are responding to this, for example by setting up R&D centres in China. The 'traditional' physical separation between low-value manufacturing and high-value innovation has become much less self-evident here. The smart factory has become *the* place where innovation on production processes and products takes place. The question for the future is thus where that smart factory will be located.[100] Clustering of innovative activities in certain regions is already apparent. More and more countries are therefore striving to be or become an attractive place for business and personnel.

In addition, more and more is earned from services linked to products. Servitization of industry is occurring, with the distinction between services and industry becoming increasingly blurred. Nike shoes, for example, now have a chip which continuously sends information back to Nike to be able to offer services to the user, such as jogging advice. The production of the shoe and the service after that (the advice in this case), two elements that were previously separate, now form a whole. Because countries such as China will, alongside low-technology production, also be involved in high-value production, they will gain more and more of a grip on other lucrative parts of the

98 Of course, all kinds of factors are involved in these choices, including wage costs, transport costs, and costs of technology development; some production processes are more location-bound, etc.

99 Interview with Sabine Pfeiffer.

100 Where production sets up also has a geopolitical dimension: the battle between countries and regions over where the advantages and disadvantages of the IT revolution end up. This is prompting questions about the role of Europe: should the EU, for example, strive more actively to provide European alternatives to American or Chinese IT solutions and platforms?

value chain. Consequently, the USA and Europe are increasingly realizing that high-technology manufacturing is important for the future of the Western economy. The Dutch 'Smart Industry Action Agenda' focuses on this.

Digitization of industrial manufacturing processes and products is becoming steadily more dependent on close cooperation between industry and services providers (Parliamentary Papers II 2013/2014, 33 625, number 105). Cooperation between industrial and internet culture is, for instance, essential (Heng 2014). As a result, there needs to be a closer focus on promoting cooperation between the industrial and service sector.[101] In view of the great role that the service sector plays in the Dutch economy, specific attention to innovation within the service sector is also important. In the 1950s, the insurance sector was one of the catalysts for automation. There is currently a growing realization again within the insurance world that it is highly necessary to find out about all manner of new innovations and figure out what they mean for the sector. The Insurancelab has been set up to speed up this process.[102] A policy trend arising from this is therefore that many parties and sectors in society, from policymakers and politicians to teachers and numerous enterprises, acquaint themselves with new technological possibilities and service providers.

Education

In the past, technology was mainly skill upgrading: it called for more skills from everyone. Heavy investment in education has meant that success has always been achieved in training people better and meeting the changing demand for skills. Education won the 'race between technology and education' (see Chapter 5). But since the advent of the second machine age, in which machines provide thinking power and where digital Taylorism makes it possible to split routine cognitive work into subtasks and to offshore, outsource, or automate them, job polarization has been evident. For the future, the expectation is that automation will affect all levels of education and cut across sectors. Currently, too, education and investment in education are cited as important in ensuring that people have the right skills for the work of the future. At the same time, it is uncertain what exactly that work – and the skills – of the future will be.

Investment in retraining and further training is needed to support redundant workers, including in the middle segment, into new work, and to enable as far as possible the middle segment to enter the higher segment. However, this is a slow and potentially painful process for the groups affected. In the Netherlands, this process takes place mainly via the influx of young people into the labour

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101 Pfeiffer (2015) indicates that German policy is fully focused on manufacturing industry. There is consequently inadequate attention on development of the service sector, while changes in that sector will possibly be even more dramatic.

102 This lab was opened by Minister Dijsselbloem on 9 June 2015 and aims to boost innovation by insurers further.

market. To match demand and supply as closely as possible, interaction between businesses and education is important (involvement of businesses in the design of curricula; strategic relationships between businesses and educational establishments). New online matching services, such as LinkedIn, may play a part in bringing about a better, faster match between demand and supply. In addition, the emergence of MOOC's could help make higher education more accessible.

Investment in primary and secondary education is important to equip children with skills considered important for the future economy and society. These entail various generic skills: skills in which people distinguish themselves from computers (working with new information, creativity, communication) or skills associated with flexibilization and a digitizing environment, such as metacognitive skills, entrepreneurship, and e-skills (learning to program, 3D printing, and the like). The platform #Onderwijs 2032, which the State Secretary for Education, Culture and Science has launched (Parliamentary Papers II 2014/2015, 29 544, number 281; Parliamentary Papers II, 31 293, number 232) focuses on the question of what skills children attending school in 2032 will need to learn in order to be well prepared for a society and labour market evolving as a result of rapid technological developments.

Prosperity
Chapter 6 shows that the information revolution and automation have mainly affected middle-class jobs since the 1980s. With the broad application of the technologies of the second machine age, the expectation is that inequality will rise further. That prompts the question of what policymakers can do to ensure the broadest possible distribution of the benefits of digitization. In this context, the European Commission talks about 'inclusive societies' in which cutting social exclusion and inequality is of prime importance (EC 2013; see also Chapter 6).

On the one hand, it is important that the government creates opportunities to ensure that many more people can earn a living in the digital economy. Access to the internet is insufficient to be able to use ICT services effectively, or be able to produce digital goods and services to earn a living. European policy therefore advocates investing in digital skills (Chapter 5 and Chapter 6). This also involves developing inclusive technology. This covers, for example, technology for people with mild disabilities and inclusive innovation: innovation for the benefit of principally poor population groups and putting the user and ease of use at the centre of things.

On the other hand, it is important that the government offers protection. The question arising in this regard concerns how to safeguard the interests of workers who have to contend with automation or platformization. This covers such things as a safe working environment, a safe number of working hours (to prevent overload and exploitation), questions concerning adequate incomes to live on, ensuring further training, and also safeguarding privacy. Under permanent employment, things of this kind are generally well regulated, and it is clear where the employer's responsibilities lie. In the case of on-demand crowdsourcing of labour, which usually does not entail an employer-employee relationship, but a client-freelancer relationship, that is not the case.[103] What rights, for not only low-skilled but also high-skilled cognitive labour, must be safeguarded? Is new social policy needed? Can this possibly even be incorporated in platforms?[104]

Linking in with this is the policy option of regulating platforms, and the monopolies newly emerging with them. Regulation is currently still often non-existent. A debate has now started in Europe, and the European Commission states that regulation is needed to promote competition and prevent the creation of monopolies.[105] Services such as UberPop are currently, for example, the subject of judicial investigation in a number of countries. At the same time, it should be pointed out that these new business models also offer important opportunities for innovation and economic growth. It is therefore important to strike a good balance here.

7.6 Closing remarks

The aim of this report has been to set out scientific insights into the relationship between technology and employment from the past and in the future. Developments in the second machine age, which we are in now, are comparable with earlier great technological revolutions. The Internet of Things is playing an ever more important role in our society. Our environment is becoming steadily 'smarter', and interaction with robots is no longer the stuff of science fiction. In this way, our society is entering a new phase. What consequences does that have? How can we put this into practice? To answer these questions, we can look back at the past. The most crucial lesson is that we can help shape the relationship between technology and work. In this regard, the 'robot society' – as previously, for example, the 'information society' – can be regarded as an inviting prospect and a mobilizing perspective. This perspective – which policymakers, administrators, and politicians can 'flesh out' – enables us to acquaint ourselves with the opportunities that the new technologies offer and further shape them ourselves.

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103 Interview with Sabine Pfeiffer and Fabian Dekker.

104 Interview with Sabine Pfeiffer. She wonders to what extent we can build fundamental values into the algorithms of platforms; examples include privacy by design or a maximum number of working hours by design, as in lorries.

105 For example, a study of abuse of market power by Google is being launched in this connection (EC 2015).

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Annex 1
Experts consulted

Prof. dr. Sabine Pfeiffer	University of Hohenheim, Germany	Sociology
Prof. dr. Bart van Ark	University of Groningen, Conference Board, New York	University of Groningen: Faculty of Economics and Business
Prof. dr. Bas ter Weel	Board of CPB, Maastricht University	Department of General Economics
Dr. Fabian Dekker	Erasmus University, WRR	Sociology
Prof. dr. Jan Luiten van Zanden	Utrecht University	Humanities

Annex 2
Technology down the ages

Various classifications

There are many ways of classifying the past from a technological perspective. This annex describes the four kinds of concepts used in our study: 1) the first and second machine age (Brynjolfsson & McAfee 2014), 2) the first, second and third industrial revolution (Mandel 1968), 3) the notion of 'generic technologies' (Bresnahan & Trajtenberg 1995), and 4) the concept of the Kondratiev wave, given that this phenomenon often plays a part in thinking about the historical relationship between technology and economics, and also in speculations about their future. In addition, we show the link between these concepts and the notion of the first and second machine age (see Tables 1 and 2).

1 First and second machine age

The terms 'first machine age' and 'second machine age', as referred to by Brynjolfsson & McAfee (2014), are of key importance in the current debate about technology and labour. The first machine age entails machines that provide muscle power, while the second entails machines that provide thinking power. The authors consider how the thinking machines (computers, robots, the internet, artificial intelligence) might change us. An important question is the extent to which we in the current age can learn from the first machine age.

2 First, second, and third industrial revolutions

In the history of technology, a distinction is often made between the first, second, and third industrial revolutions. Mandel (1968) introduced these concepts. The Netherlands' first industrial revolution between 1820 and 1870 was based on the steam engine, while the second industrial revolution was based on the electric motor and the internal combustion engine. In the 1940s Mandel (1968, p. 605) saw a third industrial revolution coming, based on nuclear energy and the use of electronic machines. This terminology has been used by others in various ways. The third industrial revolution has become increasingly similar to the IT revolution, in other words the age based on the computer.

Rifkin (2011; 2014), for example, adopts the same classification. In his view, an industrial revolution is characterized by the coming together of revolutionary developments in energy, communications, and mobility (see Table 1). The first industrial revolution entailed the combination of coal-powered steam engines and the emergence of the steam-powered printing press, the train, and railways. The second industrial age entailed the centralized production of electricity and internal combustion engines, including in cars running on oil, and the advent of radio, television, and the telephone.

Rifkin thinks that only the Internet of Things will really get the third industrial revolution going. This will underpin a smart energy network that will allow the distribution of decentrally generated energy on a large scale and a smart mobility network in which autonomous electric cars and drones will play a key part, particularly because they will be able to run on stored energy.

The first machine age refers to the first and second industrial revolution, the era in which steam engines, internal combustion engines, and electrical machines took over the muscle power of human and animals. The second machine age is another term for the third industrial revolution, the current information revolution.

3 Generic technologies

In the scientific debate about the economic influence of technology, the notion of generic technologies (general purpose technologies) is in vogue (Bresnahan & Trajtenberg 1995). This may entail products, though also processes or organizational structures. Lipsey et al. (2005) have found 24 generic technologies for the entire history of mankind. According to Lipsey et al. (2005), the first machine age comprises nine generic technologies, and the second machine age five: the computer, lean production, the internet, biotechnology, and nanotechnology.

Table 1 Overview of links between three concepts central to this study and which can be used to indicate the historical impact of technological innovation on the economy and society.

First and second machine age Brynjolfsson & McAfee (2014)	**First, second and third industrial revolutions Rifkin (2011, 2014)***	**Generic technologies Lipsey et al. (2005)**
First machine age: Machines that provide muscle power	First industrial revolution (1820-1870 / 19th century): E: Coal and steam C: Steam-powered press M: Train, railways	Factory working and standardization (late 18th century); Steam engine (18th century); Railways (mid-19th century); Iron ship (mid-19th century)
	Second industrial revolution (1870-1980 / 20th century): E: Oil and central generation of electricity C: Telephone, radio, television M: Internal comb. engine & car	Internal combustion engine (late 19th century); Electricity (late 19th century); Car (20th century); Aeroplane (20th century); Mass production (20th century)
Second machine age: Machines that provide thinking power	Third industrial revolution (1980-present / 21st century): E: Decentralized sustainable energy C: Internet of Things M: Smart electric vehicles	Computer (20th century); Lean production (20th century); Internet (20th century); Biotechnology (20th century); Nanotechnology (21st century)

*E, C and M stand for energy, communication, and mobility revolutions

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4 Kondratiev waves, technological revolutions and technoeconomic paradigms

Thinking about the relationship between technology and economics is often pitched in terms of 'Kondratiev waves'. In the 1920s and 1930s, the economists Nikolai Kondratiev and Joseph Schumpeter discovered macroeconomic cycles that occurred roughly every 50 years. Underpinning these Kondratiev waves was a cluster of technological innovations that sparked a technological revolution and new economic activities. Carlota Perez (2002) is, together with Christopher Freeman, building on these ideas which the economists Nikolai Kondratiev and Joseph Schumpeter came up with in the 1920s and 1930s. This is therefore also known as the Schumpeter-Freeman-Perez paradigm (Freeman & Perez 1988).

According to Perez (2002), a technological revolution is a "powerful and highly visible cluster of new and dynamic technologies, products, and industries, capable of bringing about an upheaval in the whole fabric of the economy and of propelling a long-term upsurge of development" (Perez 2002, p. 8). It may entail new energy sources, materials, products, production or transport processes, and infrastructure. Perez places the beginning of the first technological revolution of the second machine age (see Table 2) in 1771 in the English town of Cromford with Arkwright's construction of the first water-powered cotton mill. The steam engine and the railways are the icons of the second technological revolution that took place as from 1829. The third technological revolution started in 1875 and was the age of steel, electricity, and heavy engineering. The fourth age revolved around oil, cars, and mass production, and began in 1908, when the first Model T Ford rolled off the conveyor belt in Detroit. Perez (2002) places the beginning of the current age of information and telecommunications in 1971, with the introduction of the Intel microprocessor. In the terms of Brynjolfsson & McAfee (2014), this marks the second machine age (see Table 2).

The interesting thing about Perez's ideas (2002) is that she has conceived of the interaction between technology – in other words the five technological revolutions that she identifies – over a very long period in a systematic way from a social constructivist perspective. In her view, technical innovations allow new ways of working, organizing, and engaging in economics. The interaction between the technical and socioeconomic side determines the true transformative power of a technological revolution. Hand in hand with the technology, according to Perez (2002, p. 15), a new 'technoeconomic paradigm' develops: new trend-setting technological and organizational practices that provide the model for the most effective way that the economy can be modernized. Central to Perez's thinking is the notion that such a transition is often accompanied by severe crises, from deep economic recessions to wars. It is only in the depth of these crises, according to Perez, that the realization dawns that all kinds of new social and institutional structures are needed to distribute the costs and benefits of the new technological revolution more fairly.

Table 2 Five technological revolutions in the first and second machine age.

Brynjolfsson & McAfee (2014)	Perez (2002)
First and second machine age	Five technological revolutions from the start of the industrial revolution
First machine age: Machines that provide muscle power	I. Industrial revolution (Start 1771 in GB)
	II. Age of steam and railways (Start 1829 in GB then on to rest of Europe and US)
	III. Age of steel, electricity, and heavy engineering (Start 1875, US and Germany leading the way)
	IV. Age of oil, cars and mass production (Start 1908 in US then on to Europe)
Second machine age: Machines that provide thinking power	V. Age of information and telecommunications (Start 1971 in US then on to Europe and Asia)

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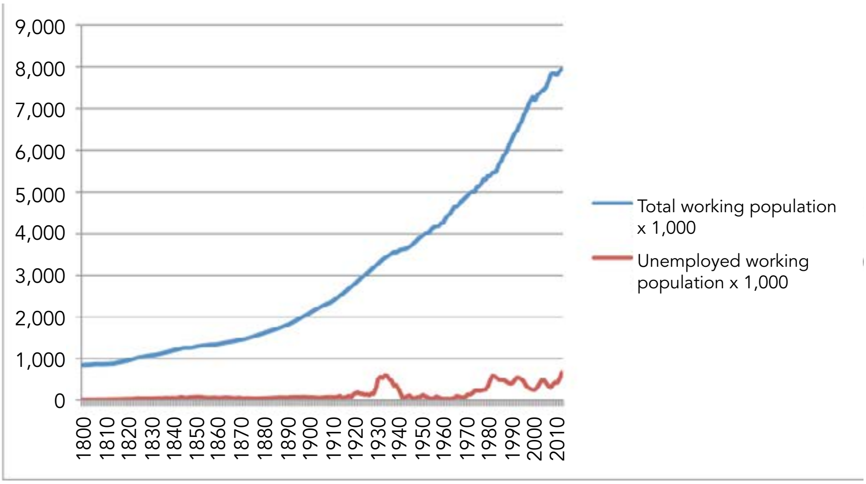
Annex 3
Evolution of working population and labour productivity

Working population

Over the last two centuries, the Dutch population grew eightfold from 2.1 million inhabitants in 1805 to 5.1 million in 1900, 10 million in 1950, 15.8 million in 2000, and 16.8 million in 2014. As the graph below shows, this population growth is reflected in the size of the working population: in other words, all persons between 15 and 65 years old who work at least 12 hours a week or who are looking for work (Statistics Netherlands).

Figure 1 Evolution of Dutch working population 1800-2013 (x 1,000)

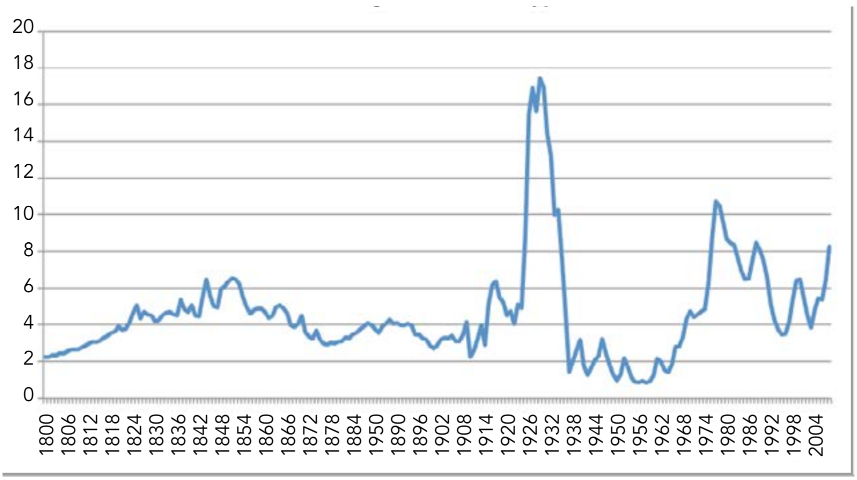


Source: Statistics Netherlands

Unemployment

In the evolution of unemployment in the Netherlands since 1800 (see graph), three periods of crisis are striking. The first is the period 1845-1855, the second is the 1930s, and the third is the period 1973-1985. In particular, fluctuations of the economic cycle played an important role in the various crises, with the open Dutch economy being susceptible to them. For example, in the 1840s declining trade in Java caused great problems for companies engaged in industry, textiles, and shipbuilding. During the same period, agriculture was confronted with dwindling harvests, in part as a result of potato blight (see, for example, Lintsen 2005; Zanden & Riel 2000). The catalyst for the crisis of the 1930s was the collapse of the international financial system and the dramatic plunge in world trade (see, for example, Zanden & Griffiths 1989, pp.129-165). In 1973, the oil crisis clearly marked an end to a period of stability and economic growth. Confidence in the economy waned, stock markets plummeted, inflation raged unabated, companies invested less, and world trade stagnated. This in turn had considerable consequences for the Dutch economy (see, for example, Zanden & Griffiths 1989, pp. 255-291).

Figure 2 Unemployment as a percentage of the working population



Source: Statistics Netherlands

Labour productivity
Labour productivity denotes production per worker and provides an initial indication of a country's technical level, prosperity, and competitiveness. In past centuries, new technologies, particularly production technologies, proved to have a substantial impact on labour productivity.

For example, labour productivity in Dutch industry grew strongly between 1860 and 1890. This was made possible by the use of steam technology in the Netherlands. Growth in the period 1890-1913 arose from the advent of the factory system and the introduction of the first gas and electric motors in small companies. The breakthrough of electricity as a new key technology boosted labour productivity in the years 1913-1938. The Second World War and wage restraint directly after the war brought about a drop in labour productivity. During the years of reconstruction, the relatively low wage costs meant that it was not interesting for entrepreneurs to invest in new labour-saving technologies. From 1950, strong growth occurred again as a result of scaling-up in industry, the development of new production lines, and ever broader use of the electric motor (Lintsen (2005) pp. 147-151).

Table 1 Mean growth of labour productivity in Dutch industry (in per cent)

Period	Mean growth of labour productivity per year in per cent
1807-1830	0.2
1830-1842	0.7
1842-1860	-0.6
1860-1890	4.8
1890-1913	1.3
1913-1921	2.3
1921-1929	3.3
1929-1938	2.3
1938-1950	-0.6
1950-1965	5.0

Source: J.P. Smits, 'The determinants of productivity growth in Dutch manufacturing, 1800-1913' (Paper presented at the workshop National Account, Utrecht 1992) and H.J. de Jong, De Nederlandse Industrie 1913-1965. Een vergelijkende analyse op basis van de productie-statistieken (doctoral thesis, Groningen 1999), p. 60.

Annex 4
Productivity explained further

The concept of productivity describes the relationship between production (output) and the means (input) needed for it. Productivity growth means that more is produced with the same means compared with an earlier period. Productivity growth is thus a measure of economic growth and at the same time of the efficiency of production. A commonly used measure that is relatively easy to calculate is 'labour productivity', which reflects the relationship between production volume and the quantity of labour expended (generally expressed as GDP divided by the number of hours worked, per worker, or per capita).

For the sake of convenience, the concept of labour productivity attributes growth in production to the factor of labour, but leaves the question of underlying factors unanswered. Besides the production factor of labour, other factors also contribute to growth, including capital goods and other inputs (materials, raw materials), as well as changes in technology. Labour productivity growth as a measure can give a very misleading picture because it does not distinguish between the contributions by these underlying factors. Breaking things down into the various components makes it possible to identify the underlying drivers and provide an explanation of the underlying reality.

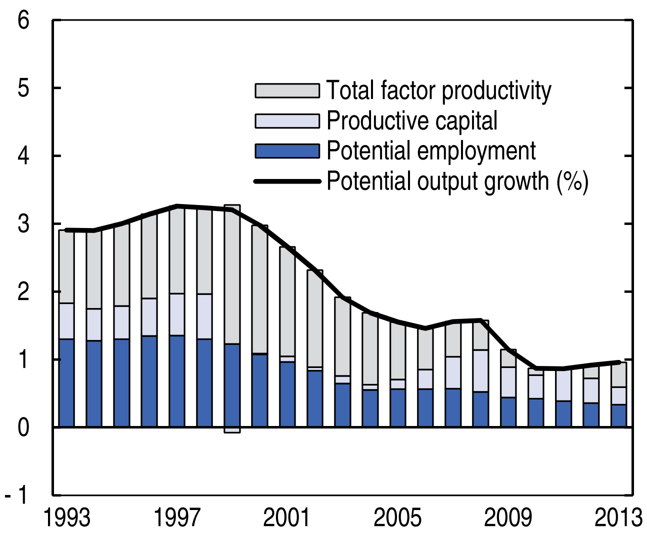
An important concept in this connection is total factor productivity (TFP), also known as multifactor productivity (MFP). A higher MFP reflects the improvement in general efficiency, combining labour, capital, and other inputs. MFP growth is in practice measured as residual growth, as that part of GDP growth that cannot be explained by the growth and composition of labour or capital. MFP encompasses notably disembodied technological change, or the impact of intangibles such as R&D, knowledge, and organization on growth in production.[106] 106 Embodied technological change in the form of technological improvement and innovation in capital goods is reflected in the factor of capital (capital deepening), including ICT. For the factor of labour, something similar applies with regard to changes in the level of education or skills intensity, also summarized under the denominator quality or labour composition.

106 However, the new empirical growth literature also increasingly regards intangibles as a separate form of capital in which enterprises invest. Intangibles encompass, in addition to R&D and artistic and product designs (innovative property), computerized information (including software) and marketing, branding, and strategic business resources (economic competencies). See also Corrado & Hulten 2010; Van Ark et al. 2009.

Annex 5 Difference between potential economic growth and economic growth

The CPB's most recent analysis for the Netherlands projects labour productivity growth of 1.1% this year and 1.3% in 2016 (see CBP 2015). This puts growth at a lower level than in 2014 (1.5%), but is considerably higher than in 2013 (0.4%). The CPB figures are consistent with the general and longer-term picture of the Dutch economy. In this context, it should also be noted that the potential growth of our economy, measured in terms of potential output (also known as trend output) the benchmark for what an economy *can* produce, has dropped sharply.[107] For the Netherlands over the period since 1993, the OECD (2014c) finds declining *potential* output growth which is trending to 1% on an annual basis in recent years (see Figure 1).

Figure 1 Breakdown of potential output growth, according to determinants (percentage points).



Source: OECD 2014.

107 The concept of potential GDP that the OECD adopts is defined as the output level that an economy can produce at a constant inflation level. Although an economy can produce more than the potential output level temporarily, this comes at the expense of rising inflation.

The OECD also identifies weakening MFP growth since the end of the 1990s, growth that in the last few years has even been trending towards zero. It should be noted that *potential* output growth is not the same as growth actually achieved (which was substantially lower the past few years), but reflects the potential scope for growth. The difference between the two is called the 'output gap'. All in all, this means that the growth of our earning power has dropped sharply in the last decade, from 3% on an annual basis to barely 1%.

Annex 6
Analysis of policy options and themes based on media articles

On the basis of scientific publications and reports, as well as comments by Minister Asscher, who called for a debate about robotization and employment, this subject has frequently come up in the media in the last year. This has prompted us to investigate what policy options the media advocate to respond to the impact of ICT developments on employment. In addition, we have investigated to what extent insights that have emerged based on analysis of policy options already form part of the public debate in the media articles. We have conducted a thematic analysis for this purpose.

Approach to analysis of policy options
We have chosen to look at written articles in the media such as national and international daily, weekly and monthly publications, because these are well documented (see Table 1 for an overview of media consulted). For instance, the Dutch-language articles have been obtained via the LexisNexis newspaper database. Combinations of the following search terms have been searched for in this database: robots, robotization, labour, jobs, work, labour unit. This yielded a list of articles, ranging from opinion articles to summary articles and interviews. We supplemented this list with international articles from publications such as *The Economist*, *The Guardian*, and *The Wall Street Journal*. Based on the search criteria, a total of 82 articles that appeared over the period January 2014 to March 2015 have been selected. For each article, we have then verified whether the articles concerned the relationship between robotization and employment (articles may, for example, also deal only with robot technology and not dwell on its impact on jobs), what was written about this relationship (leads to jobs or takes jobs), and whether they also mention policy options. Of the 57 articles dealing with the relationship between robotization and employment, 22 articles also refer to policy options. This yields a list of a number of policy options.

Table 1 Media consulted.

National daily publications	International daily publications
de Volkskrant	*The New York Times*
NRC Handelsblad	*The Guardian*
NRC Next	*Financial Times*
Trouw	*Telegraph*
Telegraaf	*The Wall Street Journal*
Algemeen Dagblad	*De Standaard*
Financieel Dagblad	*De Morgen*
Weekly and monthly publications	**Regional daily publications**
Elsevier	*Eindhovens Dagblad*
De Groene Amsterdammer	*BN De Stem / de Stentor*
The Economist	*De Twentsche Courant Tubantia*
Vrij Nederland	*Reformatorisch Dagblad*
Knack Magazine	*Dagblad van het Noorden*
Weblogs	*De Gooi- en Eemlander*
Slate	*Dagblad de Limburger*
Motherboard	*Haarlems Dagblad*
Huffington Post	

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Results

Table 2 provides an overview of the policy options mentioned in the media. The way in which these are discussed differs for each article, ranging from brief summaries of what should be done to more detailed arguments. The table shows in which articles the policy option is mentioned. The authors range from scientists (based on scientific studies) to economists, politicians, entrepreneurs, and journalists.

Various articles take various perspectives and discuss possible ways of responding to the job losses arising from technological developments. In this regard, various articles assign a role to government, politics, and society: more initiative should be taken on preventing the loss of jobs, and creating and retaining jobs. The policy options advocated for this can roughly be divided into the following clusters: business & innovation, education & skills, and labour market & prosperity.

Business & innovation

Various articles describe processes of automation or robotization as an opportunity. Robotization may lead to the loss of jobs if computers or robots take over tasks and thereby make workers redundant. However, robotization also contributes to more efficient business processes, bolstering competitiveness compared with foreign enterprises. This may lead to additional jobs in the long run.

This development must therefore not be seen as a threat to employment. Over the course of history, innovation has led to more business and economic growth. When entrepreneurs and businesses think up new products, processes, or services, they thus create new sectors that call for new skills. This ensures new jobs and employment. It is for policymakers to foster such innovation and entrepreneurship.

Education & skills

The thinking behind a number of policy options is that the educational system is in need of renewal. Investment in education, training, and retraining is therefore seen as crucial to respond to the impact of robotization on the labour market. The articles cite various policy options:

- Extending compulsory education: Extending compulsory education ensures that people are in education for longer, bringing about a higher-skilled working population. High-skilled people would be better prepared for the future labour market.

- Investing in educational resources: Investing in certain forms of education may give workers training or further training in an efficient way. An example is the inexpensive (or even free) provision of digital education.

- Lifelong learning: Training and retraining. Lifelong learning is often mentioned as necessary to be prepared for the future labour market. This entails continuously developing knowledge and skills. Workers must have the scope to be able to retrain or obtain further training at all times. Workers and employers alike are responsible for this.

- Learning skills for the future: In relation to skills, reference is commonly made to ‘skills for the future’ – skills needed for the jobs of the future. A distinction is made between skills needed to keep up with rapid technological developments, for example digital skills such as programming, and social/cognitive skills that robots cannot yet master. By developing social/cognitive skills, workers can gain an advantage over computers and robots. Examples include creativity, entrepreneurship, and critical thinking.

- Eliminating regulation: International media advocate eliminating regulation to raise the productivity of less-skilled workers. This can be done by, for example, eliminating occupational licences.

Labour market & prosperity
If unemployment increases as a result of technological developments, this must be absorbed in one way or another. The articles propose various ways of ensuring a redistribution of work and income.

- Safety net: Various articles advocate a safety net for those whose jobs are in jeopardy. There are various options for the design of this safety net. For example, the introduction of a guaranteed basic income is frequently discussed. Some even assert that the advent of the robot makes this inevitable. Another option is to raise the minimum income.

- Tax reform: Reform of the tax system is put forward as an option for helping people back to work. Taxing labour less, and taxing capital more, would make it more attractive for employers to take someone on.

- Working less: Another option is to work less. In present-day society, labour is of central importance. The taking over of tasks by robotization may ensure less work, which would have positive effects. A shorter working week is advocated, freeing up more time to be spent usefully on things such as maintaining social contacts, care, self-development, and volunteering.

- Working less or adopting a shorter working week may also ensure the retention of jobs. Workers share work to avoid being laid off, as under the *Kurzarbeit* (short-time work) schemes in Germany. The State then steps in to make up any income deficits.

- Modify working conditions: Some articles discuss working conditions. For example, they propose amending collective labour agreements and introducing more flexible working conditions to protect jobs.

Table 2 Overview of policy options

Policy option	Rationale	Mentioned in articles:
Role		
Reflection needed on this development and action needed via public policy	Society/government must absorb the loss of jobs due to technology. Politicians must take more initiative to retain and create work.	8, 28, 29, 39
Business & innovation		
Promotion of entrepreneurship	Entrepreneurs/businesses must be encouraged to develop new products and services, which can in turn lead to new sectors and industries. This new business boosts demand for new skills and creates jobs. Increased efficiency as a result of robotization will lead to additional jobs. This would also enable businesses to compete better with other countries.	29, 62
Education & skills		
Extending compulsory education	To extend the time spent at school	
Investing in education	For example: inexpensive and online provision of education	66, 68
Cooperation between universities	Cross-border pooling of manpower and resources in universities	29
Working on 'skills for the job of the future'.		25, 62, 78, 83
Promoting and developing 'technical' skills	Learning skills needed to keep pace with technological progress. For example, technical or specialist skills may help respond to technological developments such as programming or 3D printing.	20, 83
Promoting and developing social, creative, and cognitive skills	Also focus education on skills that robots do not have, or do not yet have, such as critical thinking and creativity	29, 35, 62, 78, 83
Omscholing faciliteren	Enable people to retrain if robots take over their jobs. Enterprises may have a responsibility in this, to indicate what the skills of the future will be.	23, 28, 45, 72
Promoting lifelong learning	Workers must have the opportunity to continue to learn and develop. Enterprises also have a responsibility here.	29, 33

Policy option	Rationale	In welke artikelen genoemd?
Labour market & prosperity		
Redistribution of work and income	As a society, ensure that there is a safety net (including being willing to make sacrifices and/or cut back on work)	5
Working less	Cutting back on work (a shorter working week) has advantages. For example, it releases more free time that can be spent usefully (social contacts, care, self-development, volunteering).	16, 33, 62
Sharing work	Workers get a shorter working week instead of being laid off. The State then helps make up the income deficit. (An example is *Kurzarbeit* (short time) schemes in Germany.)	66
Tax reform	Tax on wealth, capital, corporate profit, consumption, waste, and pollution takes the place of tax on labour. This makes labour less expensive. Workers keep more and can work shorter hours. It becomes more advantageous for employers to take someone on.	16, 33
Basic income (different variants are discussed here)	Distribution of a guaranteed/unconditional basic income to anyone who becomes unemployed as a result of technology (robots).	29, 33
Basic income for everyone	If it is desirable for as many people as possible to take part in the economy, a basic income is unavoidable. Governments could provide a universal basic income for all workers. This may take off in Switzerland.	62, 64
Raising the minimum income	Small increases in the minimum income may lead to productivity improvements. This arises for two reasons: turnover per worker falls or they ensure that businesses invest in workers or give workers an incentive to work harder. The risk of rising wages is that simple work is automated more quickly. To prevent this, governments could subsidize wages.	62, 66
Raising the productivity of less-skilled workers	This may be done by, for example, eliminating regulation such as occupational licensing.	66
Modifying working conditions	Amend collective labour agreements and introduce flexible working conditions.	29, 33

Approach: thematic analysis
Based on the database of articles employed for the initial assessment of policy options, we have obtained insights on themes that are important. We then examined these themes to establish to what extent they already form part of public debate in the media. These include the following themes (as also described in Chapter 7.2): 'IT as a jobs engine?', 'IT and society', and 'IT and the organization of labour'.

We conducted the thematic analysis by searching the database of 82 articles for subjects covered by these themes. For the theme 'IT as a jobs engine?', these subjects are job creation, job loss, technological unemployment, and opportunities for robotization. For the theme 'IT and society', we searched using the following search terms (or variations of them): ethical aspects, costs, benefits, regulation. For the theme 'IT and the organization of labour', we searched using the following terms: organization of labour, globalization, flexibilization, and platforms.

Results
Of the 82 articles, slightly more than half (44 articles) deal with the potential direct impact of robotization/automation: it leads to the loss of jobs or their creation. It should be pointed out that it is not illogical that the majority of these articles deal with this because the articles have been selected on the basis of the subject of robots and labour (see also: approach to analysis of policy options).

Of the 82 articles, eight Dutch-language articles deal with IT and society. They discuss ethical aspects, the costs of robotization compared with job retention, and regulation.

Of the 82 media articles, seven Dutch-language articles deal with IT and the organization of labour. They mainly concern the link between globalization and flexibilization, with just one addressing platformization.

About the authors

***Prof. dr.* Frans W.A. Brom** is Head of Technology Assessment at the Rathenau Instituut and Special Professor of Ethics of Technology Assessment at Utrecht University. He is, among other positions, Chair of the Advisory Committee on Scientific Integrity at Wageningen University and Research centre and of the Ethics and Social Aspects Subcommittee of the Genetic Modification Committee. His research investigates the significance of scientific and technological developments for society

***Dr. Ir.* Rinie van Est** is a research coordinator and trend spotter in the Department of Technology Assessment at the Rathenau Instituut. He is a physicist and political scientist and is engaged in the politics of new technologies: from nanotechnology, robotics, and persuasive technology to climate engineering and energy. He has more than fifteen years' experience in spotting scientific and technical trends and in conducting studies and debates about their social significance. He also lectures at the Department of Innovation Sciences at Eindhoven University of Technology. He has collaborated on the following books *Overal robots: Automatisering van de liefde tot de dood* (2012) and Intieme technologie: *De slag om ons lichaam en gedrag* (2014). The renowned American publisher Routledge will soon be publishing his book entitled *Just ordinary robots: Automation from love to war.*

***Dr.* Govert Gijsbers** is a senior researcher and project leader attached to the TNO Strategy and Policy expertise group. He is engaged in research and innovation policy, with a particular focus on foresight, evaluation, and impact assessment in relation to specific technologies, sectors, or social issues. In recent projects he has addressed the impact of ICT on industry, issues concerning technology, skills, and the labour market, the impact of technology on health and healthcare, and developments in the biotechnology sector. He has headed many international projects for the European Commission, for the Dutch Government, and for institutions such as the Asian Development Bank. He studied social geography and regional economics at VU University Amsterdam and obtained his doctorate at Erasmus University Rotterdam with a thesis on agricultural innovation in Asia.

***Drs.* Ira van Keulen** is a parliamentary liaison officer and senior researcher in the Department of Technology Assessment at the Rathenau Instituut. As a liaison officer, she strives to ensure an optimal link between the work of the Institute and both Houses of the Dutch Parliament. In 2013-2014 she was seconded to the Research and State Spending Office of the House of Representatives of the Dutch Parliament, where she held various positions including researcher on the Government's Temporary Committee for ICT Projects. She also works as a researcher on projects investigating the opportunities and dilemmas of e-democracy and the social impact of the neurosciences and human enhancement. Van Keulen studied Sociology at the University of Groningen and at the City University of New York.

***Drs.* Linda Kool** is a senior researcher at the Rathenau Instituut, in the Department of Technology Assessment. She conducts research on various social issues in the field of Information and Communication Technology (ICT), such as Big Data, robotics, persuasive technology, and privacy. Kool has conducted various national and international studies for the European Parliament, the European Commission, and Dutch ministries. She studied Social Science Informatics at the University of Amsterdam and has a Master's in European Studies of Society, Science and Technology (ESST) from Maastricht University and the University of Oslo.

***Dr.* Jan Korsten** has, since 1999, been Commercial Director of the Foundation for the History of Technology (SHT) attached to Eindhoven University of Technology. As a historian, he also contributes substantively to the national and international research projects initiated by SHT. His past research has covered R&D in the Dutch dairy industry, organizational and substantive aspects of the Dutch Government's handling of rural development, and the role of the Chambers of Commerce in the socioeconomic development of North Brabant. Another theme in Korsten's work is the history of cooperatives and agricultural organizations.

***Prof. dr. ir.* Harry Lintsen** is Emeritus Professor of History of Technology at Eindhoven University of Technology. He was editor-in-chief of a six-part series covering technology in the Netherlands in the nineteenth century (TIN 19) and chaired the editorial team responsible for a seven-part series covering technology in the Netherlands in the twentieth century (TIN 20). Based on this, he wrote *Made in Holland. Een techniekgeschiedenis van Nederland* [1800-2000] (Zutphen 2005). He is currently coordinating a research project investigating sustainability in the Netherlands from a long-term perspective. In addition, a major research topic in his work is the development of knowledge infrastructure in the twentieth century. He is a member of the Royal Netherlands Academy of Arts and Sciences and a Board member of the Rathenau Instituut.

***Prof. dr.* Johan Schot** is Director of SPRU (Science Policy Unit - University of Sussex) and Professor of History of Technology and Sustainability Transition Studies at that university. He previously worked as Professor of History of Technology at the Eindhoven University of Technology and the University of Twente and as Scientific Director of SHT. Schot currently heads the international research and publication programme Making Europe: Technology and Transformations 1850-2000. He was previously also programme director of Technology in the Netherlands in the 20th century (TIN20). In 2002, NWO awarded him a Vici bursary for a project exploring the role of transnational infrastructure within Europe. He is a member of the Royal Netherlands Academy of Arts and Sciences.

***Ir.* Arnoud van Waes** works as a researcher in the Department of Technology Assessment at the Rathenau Instituut. Here he has been involved in projects investigating raw materials, energy, sustainability, and the storage of radioactive waste. Van Waes studied Innovation Sciences at Eindhoven University of Technology. He also has a bachelor's degree in mechanical engineering. He has specialized in energy transition, and for his thesis he examined the debate within society about shale gas. During his studies, he has, among other things, conducted research in Nicaragua and at Aalborg University in Copenhagen.

***Dr. ir.* Frans van der Zee** is a senior strategist and project manager attached to TNO's Strategy and Policy expertise group in Delft and the Joint Institute for Innovation Policy (JIIP) in Brussels. In this role, he focuses mainly on the significance and impact of innovation and technology for economics and society, in foresight studies, evaluations, and opinions on innovation policy, both in the Netherlands and in Europe. He has directed various projects exploring the role and significance of ICT and technology, and was recently involved in leading studies of Key Enabling Technologies (KETs) in Europe, Smart Industry in the Netherlands, and open innovation, including a study for the European Parliament (to be published). He has also directed the European Sectoral Innovation Watch, nine studies of the future that are in preparation and arise from the European flagship initiative New Skills and New Jobs, and was involved as final editor on the Jaarboek ICT en Samenleving 2012. He studied economics at Wageningen University and the Network for Quantitative Economics (NAKE), obtained his doctorate with a thesis on the new political economics of European agricultural policy, and then worked as a university lecturer (WUR, Erasmus University Rotterdam), a senior economist at Ecorys, and a director of SEOR-ESE.

Who was Rathenau?

The Rathenau Instituut is named after Professor G.W. Rathenau (1911-1989). Rathenau was consecutively Professor of Experimental Physics at the University of Amsterdam, Director of the Philips Physics Laboratory in Eindhoven, and a member of the Scientific Advisory Council on Government Policy. He gained a national reputation as Chair of the committee given the task in 1978 of investigating the consequences for society of the advent of microelectronics. One of the recommendations in the report was the production of a systematic study of the significance of technology for society. Rathenau's activities contributed to the establishment of the Netherlands Organization for Technological Assessment (NOTA) in 1986. NOTA was renamed the Rathenau Instituut on 2 June 1994.

We are increasingly coming into contact with robots and far-reaching automation. Examples include robot vacuum cleaners, self-scanning checkouts, and online tools enabling you to draw up legal contracts yourself. The debate about what this automation will mean for future employment has now started in media, science, and politics. Some see opportunities with new possibilities for more comfort, health, and economic growth. Others worry about whether 'smart technology' will replace jobs.

This report deals with this last question. What does the use of smart technology mean for employment? What tasks can smart technology take over from humans, and where do humans and machines complement one another? How is the organization of labour and production processes changing, and what impact does this have on the automation of work? Are certain groups on the labour market more vulnerable than others? What policy measures can we adopt to exploit the opportunities of automation and prevent negative effects as far as possible?

The report *Working on the robot society* sets out current scientific findings for the relationship between technology and employment. It looks at the future and describes the policy options. In so doing, the report provides a joint fund of knowledge for societal and political debate on how the Netherlands can organize a robot society that is an enticing prospect for all.

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