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THE NETHERLANDS SCIENTIFIC COUNCIL FOR GOVERNMENT POLICY

Mastering the Robot

The Future of Work in the Second Machine Age

Robert Went, Monique Kremer & André Knottnerus

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The Netherlands Scientific Council for Government Policy (WRR) is an independent think-tank for the Dutch government. It provides the government with advice, both on request and of its own accord, from a long-term perspective. The topics are cross-sectoral and cover social issues with which the government may need to deal in the future.

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Robert Went, Monique Kremer and André Knottnerus

'Will robots steal our jobs?' 'Scared of robots? You're right to be.' 'Watch out for the robots!' These are just a few examples of recent print and TV news headlines in the Dutch media. It's as if a 'robot alarm' has gone off in the Netherlands in the past few years. The robots are coming, and because they're getting better and smarter all the time, they could take over many of our jobs. There is a connection between the shrill headlines and recent research, with a controversial study at Oxford generating much of the media hype. The researchers, Carl Frey and Michael Osborne (2013), forecast that 47% of all jobs in the USA could be computerised in twenty years' time. Telemarketers, insurance underwriters and mathematical technicians top their long list of high-risk occupations. Low-risk occupations include recreational therapists and healthcare social workers. Deloitte (2014) reproduced the British study in the Netherlands with equally sensational results.

But we also find robots fascinating and valuable in certain contexts. There have been countless news items in the media about Google's self-driving car, for example, with searches (in Google, naturally) turning up some 900 million hits. The use of robots in health care has also generated a lot of interest. According to reports, the therapeutic robot seal Paro is brightening the lives of elderly people with dementia, and there is even a full-length documentary about Alice, a sociobot, and how it interacts with an elderly Dutch woman. These media reports consistently put a more positive spin on the future of work. 'Robot vacuum cleaner takes the pressure off,' reported one Dutch newspaper in June 2015. A robot can lighten the working person's burden considerably. Many such reports reference the economist John Maynard Keynes, who predicted back in 1930 that technology and machines could lead to a 15-hour working week. People would finally be liberated from the need to work and have a lot of time off.

These debates prompted the Netherlands Scientific Council for Government Policy (WRR) to consider robotisation and the future of work. The result is the study *De robot de baas. De toekomst van werk in het tweede machine tijdperk* (Mastering the Robot. The Future of Work in the Second Machine Age), consisting of the present essay and six contributions by technology experts, economists and other academics from the Netherlands and elsewhere (Linda Kool and Rinie van Est; Martijn Wisse; Bas ter Weel and Wiljan van den Berge: Edward Skidelsky; Richard Freeman; Casper Thomas). In addition, a collection of short texts (by Fabian Dekker, Anna Salomons, Kees Marges, Jan Popma, Monique Kremer and Robert Went) describe the actual or potential impact of new or existing technologies on the real world of the labour market. Last but not least, Jon Turney has written a glossary for us. We have made grateful use of all these contributions in our analysis and in the ideas that we propose in the essay that has been translated into English for this publication. We presented *De robot de baas* to the Dutch Deputy Prime Minister and Minister of Social Affairs and Employment, Lodewijk Asscher, on 8 December 2015.

The study does not offer any utopian or dystopian predictions about the future of work. Neither does it include lists of occupations or the latest high-tech gadgets. The question we address here is more exploratory in nature: What do and what can digitisation and robotisation mean for the future of work? We look at three issues in greater depth. The first is: Viewed from a labour-market perspective, which forms of robotisation (and digitisation) will we see, both now and in the future, and what are the contributing factors? The second question is: What do we know about the consequences of digitisation and robotisation for work? The third and final question is: Which issues should government be addressing in policy, and what action can be taken by researchers, employers and employees, their representative organisations, and other parties?

In the their essay Robert Went and Monique Kremer offer some initial pointers for mastering robotisation and digitisation. Based on the ideas described above, a literature review and interviews with researchers, policymakers and practical experts, they argue that the Netherlands needs a broad, 'inclusive robot agenda'. That agenda is important not only for the Dutch government but also for researchers, employers and employees, their representative organisations, and other stakeholders (e.g. users). To take advantage of new opportunities and offset any real or potential disadvantages, politicians and the public must take action. That explains the title of this publication, *Mastering the Robot*.

The key word in their proposed agenda is *complementarity*. The point is not to replace as many people as possible with robots, but rather to *use* robotics to make people more productive. It is important to strive for *inclusive robotisation*. Although robots and other machines are getting smarter, technological advances and applications often turn out differently than expected or proceed more slowly than claimed. Crucially, government must encourage the different parties involved in robotisation to work together. It is important to seek opportunities for *co-creation*, in which it is not the *techies* who come up with new applications for the workers, but rather the techies and the workers who develop the applications together. This should be the first item on the 'inclusive robot agenda'.

The second item is to *develop complementary expertise and skills* at all levels of education. A good education is not in itself enough to anticipate the rise of increasingly intelligent machines. Even accountants, physicians, lawyers and other highly educated professionals may see certain aspects of their work being taken over by robots one day. Neither is technical training alone likely to be enough. The real question including with respect to education should be: What is typically human about the work we do? Which tasks, relationships and responsibilities will continue to require the human touch, or will we specifically want to entrust (or continue to entrust) to people? That is why it is important to consider and identify complementary expertise and skills.

The third item on the inclusive robot agenda is *ownership of work*. A common finding in studies about stress in the workplace, burnout and on the positive side work enjoyment and productivity is that autonomy or 'ownership' is good for productivity. The question is how we can get people and technology working together, and how people can continue to master their own work (and the robot).

The fourth topic is *new issues of inequality*. Some people will be unable to keep up with the roboticised society. It is impossible to predict who they will be. Who will find themselves jobless, or will require retraining for another job? Policymakers therefore need to create a portfolio of measures that will help and support people where necessary. It is also important to consider whether workers can (and should) become co-owners of robots and other machines, as we believe that co-ownership is one way in which workers can continue to master robots.

We hope that this 'inclusive robot agenda' will resonate beyond the Netherlands and that our analysis and ideas will provide useful inspiration to consider robotisation and the future of work elsewhere.

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1 HOW TO MASTER ROBOTISATION. FOCUS ON COMPLEMENTARITY

Robert Went and Monique Kremer[1]

1.1 INTRODUCTION

The cybernation revolution will result in a system 'of almost unlimited productive capacity which requires progressively less human labor.' These words date from 1964 and can be found in an open letter by the Ad Hoc Commission on the Triple Revolution. 'It is essential,' the Commission wrote, 'to recognize that the traditional link between jobs and incomes is being broken. The economy of abundance can sustain all citizens in comfort and economic security whether or not they engage in what is commonly reckoned as work.' The Commission members included such illustrious names as Michael Harrington, Robert L. Heilbroner, and Nobel laureates Gunnar Myrdal and Linus Pauling. Sent in March 1964 to President Lyndon B. Johnson, the US Secretary of Labor, and the Majority and Minority leaders of the US Senate and House of Representatives, the open letter attracted considerable attention. Newspapers editorialised about it, and it was front-page news in the *New York Times*. President Johnson put together a National Commission on Technology, Automation, and Economic Progress and, while signing the relevant bill into law, stated that 'automation can be the ally of our prosperity if we will just look ahead, if we will understand what is to come, and if we will set our course wisely after proper planning for the future.' This optimistic view was undoubtedly inspired by the USA's flourishing economy and low unemployment figures in the 1960s.

Thirty years later, however, the picture had changed utterly and completely. In the 1990s, new technology – especially cheap computers and smart software – came to be viewed as a threat. When IBM, General Motors and Boeing made tens of thousands of employees redundant, there was widespread fear that mid-level jobs would simply disappear. Intellectuals wrote about a jobless future (Aronowitz and DiFazio 1994) and a world without workers (Rifkin 1994). The new science of information technology was thought to be leading us to the start of a third industrial revolution, following that of the steam engine (the first revolution) and electricity (the second revolution). But after a while, the fear of technology leading to massive job losses began to fade. By the mid-1990s, the economy began to recover and the 'dot.com' bubble became the next big thing (Carr 2015).

Two decades have now passed and the consequences of digitisation and robotics are once again drawing attention. Technological innovations are speeding up the development of robotics and expanding its potential. Once again, people are asking whether robots will soon be taking over many existing jobs. MIT experts Brynjolfsson and McAfee (2014) claim that a second machine age has dawned. While the first machine age was about machines that produced muscle power, the second is about 'intelligent machines' that deliver mental power. This latest revolution has three features: everything is faster, everything can be digitised, and there will be new, unexpected and unpredictable combinations (Brynjolfsson and McAfee 2014; Cowen 2013; Van Est and Kool 2015).

By now, there have been numerous reports and articles estimating or 'predicting' how many jobs are set to disappear. Frey and Osborne (2013) have forecast that 47% of jobs in the USA will be lost to computerisation. Using the same method, Bruegel (2014) estimates that figure at 49.5% in the Netherlands. New international comparative research also identifies those segments of the labour market in which jobs are under pressure (Goos et al. 2014).

One significant way in which the situation today differs from the USA in the 1960s is the less optimistic economic context. The global economic slowdown has now lasted several years, leading international organisations to worry about the current state of the world economy. Gordon (2012) has identified six 'headwinds' that are impeding growth. In his analysis, one of the main headwinds is that the positive impact of the computer and internet revolution on productivity has withered away, and that inventions are not expected to generate much more growth. Looking ahead, we see that the population in the West is ageing. Population growth is static or even negative, leading to a decline in the number of hours worked.
The IMF and the OECD have pointed out that the growing inequality evident in many countries is bad for economic growth; they advocate the active promotion of 'inclusive growth', that is growth that is beneficial for all. In October 2015, for the fifth year in succession, the IMF revised its growth forecast for emerging economies downwards, this time to a meagre 3.1% in 2016. Many economists believe that a period of *long-term secular stagnation* (a condition of negligible or no economic growth) has begun (Teulings and Baldwin 2014).

Those who see slow economic growth as a long-term problem ignore how much computerisation and robotics can increase labour productivity, leading to faster growth. Some economists (including McAfee and Brynjolfsson) are optimistic and do not foresee long-term stagnation. On the contrary, they anticipate that robots, Big Data and self-driving vehicles will generate more growth and prosperity, for example by creating a bigger 'consumer surplus', as economists call it, i.e. the difference between what consumers are willing and able to pay for a good and what they actually do pay, i.e. the market price.[2]

The question that we address in this chapter is what robotisation and progressive digitisation can and do mean for the future of work. We start by describing the relevant advances in technology, borrowing from Brynjolfsson and McAfee's concept of the 'second machine age' (2014). The basic premise is that we are at the dawn of a new phase in digitisation and computerisation brought about by faster computing power, improved sensors, Big Data, and technology that is capable of creating and doing whatever we want (such as 3D printers and 'real robots'). Against this background, we look at the influence of robotisation on mental power and, as a result, on work. We then ask which factors are important for the ongoing development and implementation of new applications. We subsequently consider what this means for work. For example, can we already say which jobs are or will be under threat and how jobs today will change in the future? The final section provides an outline for an 'inclusive robot agenda' for the Netherlands.

1.2 A NEW PHASE IN THE DIGITAL REVOLUTION: THE SECOND MACHINE AGE

Robots as depicted in the media and in discussions often resemble the creations of science fiction films and literature. There, they are angular, iron dolls that wander into our factories, living rooms and hospitals, sometimes speaking in a tinny voice. But such a narrow definition of robots ignores many of the important developments now under way. 'Robots are the most recent expression of the rise and diffusion of ICT and may well have a huge impact on the labour market,' write Van den Berge and Ter Weel (2015a). They are referring to more than the impact of factory robots, merely one part of a much broader digital transformation (see also Kool and Van Est 2015). The term 'robots' refers not only to physical robots, but also to 'technologies such as "softbots", artificial intelligence, sensor networks and data analytics. This is the Internet of Robotic Things, in which the internet is extended by senses (sensors), hands and feet (actuators) and, thanks to machine learning and artificial intelligence, can also be "smart" (Van Est and Kool 2015). This study adheres to this broader definition of robots. In the words of Freeman (2015), it concerns 'robots and other machines'.

Robots and other machines come in all shapes and sizes (Hueck and Went 2014). They range from industrial and service robotics to artificial intelligence. Industrial robotics is not a very fast-moving field yet. According to the most recent figures collected by the International Federation of Robotics (IFR), there are currently more than 1.4 million industrial robots at work around the world. The number has been increasing for many years and will continue to do so, but not exponentially, the IFR predicts. The same figures show that the Netherlands has 8470 industrial robots, or 93 per 10,000 workers in industry. By comparison, South Korea has 437 robots per 10,000 workers (Bouman 2015).

According to the IFR, 24,207 service robots were active around the world in 2014, most of them in agriculture and defence. Since 1998, a total of about 172,000 service robots for professional use have been sold. How many are still in operation is unknown. In 2014, 4.7 million service robots for personal and domestic use were sold, for example vacuum cleaners and lawn mowers (IFR 2015). Industrial and service robots are robots in the 'narrow' sense of the word. Artificial intelligence refers to machines that can also 'think' for themselves and can learn from our behaviour so that they subsequently take it into account. Many new robotic applications are not immediately distinguishable as such. Consider that an in-car sat nav system, the check-in/check-out gates at the train station, and a smart thermostat are all examples of robotics.

Many discussions centre on the potential of technologies and new applications that are still being developed or tested. In the following, we consider which factors are important for the ongoing development of robotics and the use of applications. It will become clear that what works in theory may not actually be feasible on a larger scale. Key factors are 1) technology is often more limited than anticipated, 2) the level of investment in robotics is still too low, 3) the cost to users is still too high, 4) people aren't always keen to have the latest technologies and gadgets, and 5) the legal frameworks have yet to be put into place.

WE WANTED FLYING CARS...

In 2011, Peter Thiel, PayPal co-founder and Facebook investor, complained in a manifesto that '[w]e wanted flying cars, instead we got 140 characters' (referring to Twitter). We still don't have jetpacks and opinions differ as to when self-driving cars will become commonplace. Technological innovation often makes its way into our everyday lives much more slowly than expected or forecast by inventors and investors, who often have a major interest in ratcheting up expectations.

One reason for this may be that the practical obstacles are often underestimated. When Foxconn wanted to replace a million employees in China with robots – which, after all, never need to sleep and can assemble iPads and iPhones 24/7 it soon became clear that the robots were not precise enough to do the work being carried out by human beings. The company had to abandon its plan and rehire employees – at least for now, because better robots are already on the drawing board.

There are also coordination and organisational problems that can only be solved in the course of time. For example, for several years now there have been high hopes concerning 'the internet of things', but useful applications require a certain amount of coordination between the parties involved. Baily and Manyika (2015) of the Brookings Institute claim that the internet of things is currently peaking in the hype cycle of emerging technologies, but Japan was already marketing the first refrigerator that could reorder milk back in 1998. Several different companies had developed an online refrigerator at that point, but they were not commercial successes. David Langley (2015) says that cross-sector cooperation is necessary for such success because no single party has all the knowledge and resources needed to market a smart device on its own. A smart refrigerator, for example, requires sensor technology, internet technology, an innovative user interface, food, delivery processes for fresh products, and household appliance and refrigeration technology.

Intelligent machines are often slower to be integrated into the human world than expected or hoped. Although there has been considerable progress in recent years, MIT expert Daniela Rus (2015) believes that robots have three problems: 1) production of new robots is slow; 2) their ability to perceive and reason about their surroundings is limited; and 3) robot communication is still 'brittle'.

In addition to the technical limitations, the time factor and the costing, the question is whether people necessarily want something, even if it's possible. Does everyone actually want to be chauffeured around in a self-driving car? There will surely be those who, for whatever reason, want to keep their traditional cars, even after self-driving vehicles become available. Car manufacturers will naturally respond to this by making their products safer and adding more features. Toyota (*Financial Times* 2015) has already stated that it does not see drivers being taken out the equation altogether, even in the longer term. The most interesting question is whether driverless and traditional cars can co-exist, or whether a 'dictatorial' top-down solution will be needed that makes driving a car oneself illegal, as foreseen by Samit (2015) (see also Roberts 2015).

DON'T UNDERRATE PEOPLE

Various authors have pointed out that analysts concerned about digitisation and 'software' robots should not forget how unique human beings actually are. Fifty years ago, NASA described man as 'the lowest-cost, 150-pound, nonlinear, all-purpose computer system, which can be mass-produced by unskilled labor' (Brynjolfsson and McAfee 2015). But people have the power of empathy and, unlike machines, they are capable of coming up with useful ideas and creative solutions to problems (Colvin 2015; Toyama 2015).

Colvin (2015) argues that we should not be focusing on what robots cannot do yet. The goalposts are shifting all the time and our predictions often turn out to be embarrassingly wrong – after all, until recently no one thought that a self-driving car would ever be possible. It is a much better strategy to ask what activities *should* be performed by humans, or will we *insist* that other humans perform. Judges have the help of computer algorithms that search case law and assist in organising the material, but it is judges, and not robots, who will continue to issue court rulings for the time being, since what matters is 'the social necessity that individuals be accountable for important decisions' (Colvin 2015: 43). The same is true of CEOs, military generals and public administrators. The implications of this strategy for education and future skills are discussed by Freeman (2015).

People's wishes and needs are not uniform and predictable. While Japanese sushi chain Kura has replaced its chefs and wait staff in 262 restaurants with robots (Ford 2015), McDonald's is experimenting with the opposite strategy in Britain by employing wait staff. Another example is the Apple Store, which has dozens of experts on hand to instruct and inform customers about iPads and iPhones. This is very different to shops that retain a barebones staff because they are competing on price. That's why assistants and wait staff are unlikely to be replaced by robots in all the shops, bars and restaurants of the future. More plausible is that the two will co-exist, along with a variety of intermediate forms. It's impossible to predict whether there will be a preponderance of one or the other. It all depends on consumer preferences.

PUBLIC SUPPORT

We're fooling ourselves if we imagine that machines – whether we mean driverless cars or conveyor belts in restaurants – will ever operate entirely flawlessly. Carr (2015) warns us that they have the flaws and vulnerabilities of their creators. Sooner or later, even the most advanced technology will go pear-shaped, or a computer system will have to cope with circumstances that its designers and programmers had not anticipated and for which the algorithm has no response. Carr also warns about unpredictable cascade effects in increasingly interlinked networks: 'Autonomous cars don't drive the streets of Utopia.'

In the same context, Autor (2014) makes a relevant distinction between rules-based logic and machine learning. Rules-based logic is error free (because computers never make mistakes in calculations), but its inflexibility means that its usefulness is limited. Machine-learning, on the other hand, constantly runs the risk of errors because it involves estimates based on statistical and/or mathematical models. That is why if machine learning becomes more powerful, we will also need more people to monitor, translate and 'judge' the machine's decisions, which will be based, for example, on the statistical analysis of Big Data (see Kool and Van Est 2015).

Finally, difficult ethical questions may arise that require thoughtful consideration, or there may be legal issues that must be settled before we can make widespread use of driverless cars, drones and other new robotics and AI applications. One problem in the context of the law, for example, concerns the liability of robots. Several of our authors note that there is, as yet, no legal framework for liability issues of this kind. Similar questions are relevant in the case of self-driving cars. Who decides which life to save in an impending accident, the driver or the child that has darted into the road?

TIME FOR INFLUENCE

Even if something is possible technically, that does not mean that it will immediately be accepted by the general public, quickly become reality, and have a successful, across-the-board introduction (Went 2015). Much has to happen between the invention of a technological innovation and its large-scale practical application, for example investment in the right user-friendly technology and infrastructure, amendments to the law, adaptations in work organisation, cultural acceptance, the time it takes to scale up an innovation, and – last but not least – the costs involved in utilisation and maintenance. The benefits of an application must outweigh the costs. When the price of microchips, robots and computers falls, their large-scale utilisation thus becomes easier (*Het Financieele Dagblad,* 3 October 2015). But all of this takes time, and the diffusion of many inventions and new products is slow (see Manuelli and Seshadri 2014 about the introduction of tractors).

There are, in short, good reasons for not introducing every new technology or application as soon as it is developed, and certainly not on a mass scale. The obstacles are economic, institutional, political and societal. The reason we have raised this issue is not to underplay or minimise what lies ahead. On the contrary, the point is that politicians, civil society, businesses and consumers can try to influence the direction of new technology and set limits on its development.

After all, technology doesn't just 'happen'. It can be influenced. That is one of the main conclusions of the Rathenau Institute's study (Van Est and Kool 2015). The way in which technology is advancing and being used is by no means a foregone conclusion (Brynjolfsson and McAfee 2014, 2015; Markoff 2015). One important difference between people and horses, a factor of production that was replaced by machines not so long ago, is that people can rebel, note Brynjolfsson and McAfee (2015): 'The horse population accepted its economic irrelevance with not a murmur of protest (as far as we can tell). If the same happens to human workers, they are unlikely to be so meek.'

1.3 HOW TECHNOLOGY IS CHANGING WORK

As we said before, many people are worried and have questions about the consequences of ongoing digitisation and robotics for work. Will there still be jobs in the future, and if so, who will fill them? What sort of work will they be doing? We still know too little about the impact of robotics and other new applications. What can we learn from what we *do* know?

WILL ROBOTS BE DOING OUR JOBS?

There has been a steady stream of alarming articles and reports in recent years about the future of work. Their authors predict that robots and other machines will be taking over half of all existing jobs within twenty years (Frey and Osborne 2013; Deloitte 2014; Bruegel 2014). These studies are based on the approach taken by David Autor and his co-authors, who showed that the USA is in the midst of what they call 'routine-biased technological change' (Autor et al. 2003). They look at the degree to which tasks are 'routinisable' (codifiable), as this means that they can be carried out by computers and other machines. However, these alarming studies, which have attracted considerable media attention, largely neglect the fact that there will also be new jobs in the future. A growing demand for both existing and new goods and services (generated by falling prices owing to rising productivity) can lead to new jobs. New types of jobs will also emerge, for example those of creating, programming and maintaining robots. A considerable proportion of young people will not be replacing older workers, but instead going into new and fast-growing occupations (OECD 2012).

Lessons learned in the past are no guarantee for the future, but history shows that previous technological revolutions (the steam engine, electricity and ICT) wiped away old job categories and created new ones. For example, the birth of the computer made information science much more important. That is why a new higher technical training programme was created in the Netherlands in the 1970s, as Korsten et al. show in their historical survey, part of the Rathenau Institute study referenced earlier (Van Est and Kool 2015). Change does not happen overnight; it is a gradual process, they write. 'In the Netherlands, generic new technologies have so far not led to lasting labour market crises. Nevertheless, the introduction of new technologies in the labour market has always created the need to better coordinate labour supply and demand, for example by means of education' (Van Est and Kool 2015: 85).

THE MIDDLE UNDER PRESSURE

There are signs that digitisation and its applications have impacted the various segments of the labour market differently in the past few years. Graetz and Michaels (2015) studied the impact of industrial robots in 17 countries between 1993 and 2007 and concluded that in that period, the introduction of robots (in the narrow sense of the word) was not associated with a decline in employment. However, there were, they observe, inequality effects, with low- and middling-skill workers having fewer opportunities. The same observation can be found in research on the consequences of digitisation and offshoring. In their international comparative study, Goos et al. (2014) show that the period 1993 to 2006 was one of 'job polarisation', with 'middling occupations' – the middle segment of the labour market – shrinking (see also Goos et al. 2009).

In *De robot de baas* (Van den Berge and Ter Weel 2015a) and in a *Policy Brief* issued by the Netherlands Bureau for Economic Policy Analysis (Van den Berge and Ter Weel 2015b), Van den Berge and Ter Weel conclude that the same has happened in the Netherlands over the past fifteen years, although less dramatically than in many other countries. Jobs at the lower end of the middle segment are disappearing, and the people who become unemployed as a result often end up taking new jobs on an even lower rung of the ladder. Jobs are also disappearing at the upper end of the middle segment, and many of those workers end up in jobs on a higher rung. The researchers conclude that a new dividing line has opened up between mid-level workers. They also point out that job content and occupational activities are changing. Secretaries, who used to spend most of their working hours typing, answering the phone and distributing faxes, now have other tasks for example scheduling and project management. The biggest changes, in other words, concern the actual job *tasks*.

Studies involving data analysis are, of course, retrospective in nature. They help us understand what has already happened, and we can learn a great deal from history. But no one knows whether the trends and developments of the past will continue in the future. There is no way of predicting whether technological advances will continue impacting the middle segment. Algorithms and smart machines could just as easily pose a growing threat to jobs at the higher end of the labour market. Which high-skilled tasks can be routinised depends, among other things, on how smart machines become. According to Ford (2015), machines will in fact grow increasingly capable of performing predictable human tasks as well. Physicians, accountants and lawyers may therefore also feel the effects in time.

At the moment, we do not know the potential of deep learning (in which robots learn and generalise by processing huge numbers of examples) and cloud robotics (in which every robot learns from the experiences of other robots), and their impact on existing and possible new human tasks (Pratt 2015). Autor (2015), an authority on computerisation and the division of labour, does not expect the job polarisation trend of recent years to continue endlessly. Many mid-level jobs actually cluster specific occupational skills with such basic skills as literacy, numeracy, adaptability, problem-solving ability and common sense. He conjectures that such jobs cannot easily be divided into mid-level activities for machines and lower-level activities for people without a loss of quality.

More economic inequality?

'As the technologies of the second machine age become common, there is a very real risk of growing inequality in the future,' writes the Rathenau Institute in its report for the Dutch House of Representatives (Van Est and Kool 2015).
The impact will be felt both on opportunities and on income and capital. In its aforementioned *Policy Brief* on job polarisation (Van den Berge and Ter Weel

2015b), the Netherlands Bureau for Economic Policy Analysis stated that 'the rise of ICT since the 1980s has led to growing wage inequality between high-skill and low-skill workers and, recently, to a decline in employment and pressure on wages in the middle segment' (see also Kremer et al. 2014). What will happen to incomes in future remains to be seen. What is certain, however, is that some people will benefit more from technological progress than others. Conversely, there will also be people who suffer when a new technology is introduced.

For some time now, economists have been discussing skill-biased technological change,[3] or technological innovation that is advantageous for high-skill workers. A more recent discussion concerns capital-biased technological change, or technological innovation that is mainly advantageous to those who own robots (Cohen-Setton 2012; Krugman 2012). Richard Freeman (2015) states that robots and related technologies are growing more and more capable of taking over all sorts of workers' tasks, and that the economic position of labour versus that of capital is deteriorating as a result. 'Unless workers earn income from capital as well as from labour, the trend toward a more unequal income distribution is likely to continue, and the world will increasingly turn into a new form of economic feudalism. We have to widen the ownership of business capital if we hope to prevent such a polarization of our economies.'

JOB CONTENT: THE QUALITY OF WORK

It is important to consider how robotics will change the content of our work. Philosopher Edward Skidelsky (2015) points out the possible disadvantages of the ongoing mechanisation of services, also known as 'digital Taylorism': 'Procedures are standardised. The scope of judgement and trust is narrowed,' he argues. He is very critical of what that means for workers. In his view, it means that '[l]abour is de-skilled and its bargaining power eroded a factor in growing income inequality… And patients, students and customers are made to feel that they are objects of a purely impersonal process, for which no one is responsible and no one cares' (see also Bergvall-Kåreborn and Howcroft 2014).

In the service sector, mechanisation and digitisation are changing the relationship between the service provider and the customer, but the nature of the work may also change. In *Mindless*, Simon Head (2014) shows that employees can be monitored every second of their working day once management and smart machines are connected. He gives the examples of Walmart and Amazon, where employees have to become almost robot-like in order to do their jobs. In her essay, Anna Salomons (2015) shows how counterproductive this is and how much it impedes innovation: 'Treating employees like robots erodes the productivity gains that can be made by introducing real robots.'

To give a more concrete example, smartphones can be useful for nurses because they allow them to supply patients immediately with information. However, they also make it possible to track nurses continually as they work and nudge them where necessary. In that case, digitisation may reduce autonomy and self-actualisation (Carr 2015). That is not inevitability, but a choice, because digitisation can also make work more pleasant and varied. In the USA, for example, start-up firms are working on applications that will make the working and personal lives of those on the lower end of the labour market more agreeable and transparent (DePillis 2015; O'Reilly 2015).

Mismatch

In sum, it is impossible for us to predict how robots and other smart machines will affect work and the labour market. Some jobs will disappear, other jobs will change, and new jobs will be created. There will undoubtedly be certain groups of people who are unable to keep up, either temporarily or permanently. Those who lose their jobs will not always move into one of the new ones. There will be mismatches, as the CIO of Aegon relates in the study *De robot de baas* (Went and Kremer 2015). The insurance world needs fewer mid-level employees, but high-skill individuals who combine a technical background with creativity are more than welcome. That means that, similar to today, we need a sound policy on education and income to guide technological innovation. And that is in fact our next topic.

1.4 Towards an inclusive robot agenda

Many domestic and international discussions about robotics focus on whether it will lead to huge job losses and how young people and employees can be properly prepared (in school and through training) for what the Rathenau Institute has called 'the roboticised society' (Van Est and Kool 2015). All this is relevant, but we believe that the Netherlands needs an 'inclusive robot agenda' that looks beyond these concerns. It should serve to prepare us for the changes ahead and to influence the nature of those changes. The robot agenda is important not only for the Dutch government but also for researchers, employers and employees, their representative organisations, and other stakeholders (e.g. users).

Technology doesn't just happen to you

'Too often technology is discussed as if it has come from another planet and has just arrived on Earth,' says LSE professor Anthony Atkinson (*MIT Technology Review 2015*; Atkinson 2015; Mazzucato 2013). But the trajectory of technological progress and innovation depends not only on what is technically possible and on economic interests, but also on choices by engineers, governments, businesses, employees, unions and consumers. Markoff (2015) describes how two different schools of thought arose in the engineering community of the 1960s about the relationship between humans and computers and robots. In the Artificial Intelligence (AI) school, the point is to replace people by machines, whereas in the Intelligence Augmentation (IA) school, the aim is to use computers to improve human learning and drive human innovation. These two schools still exist alongside and in opposition to each other (and they don't talk nearly enough, according to Markoff). There is no predetermined path along which robotics and AI will develop.

The Council's report on the learning economy (WRR 2013) shows that the Netherlands will need every single worker, each one working at his or her own level, to maintain a robust and innovative economy. Following the philosophy of Intelligent Augmentation (IA), we argue below that what we must focus on when developing new technologies and applications is *complementarity* between humans and machines, regardless of the kind of work. That will not always be feasible or easy. New technologies have their origins around the world, and as often as not they are the products of major international players. But the Netherlands, and Europe with it, can in any event aim to create more scope for *inclusive technology*.

Our ability to influence digitisation and robotics has been emphasised by a group of thirty leading American technologists, economists and investors. In June 2015, they published an *Open Letter on the Digital Economy*. Among the signatories, many of them associated with MIT, were Erik Brynjolfsson, Andy McAfee, Laura Tyson, Nobel laureate Michael Spence, Mustafa Suleyman and Vinod Khosla. We are in the early stages of an era of great technological change, they write, but the benefits of this technological surge have been very uneven. Many people are asking, will robots eat our jobs? 'We think this is the wrong question, because it assumes that we are powerless to alter or shape the effects of technological change on labor.' They recommend making some basic changes to public policy (in the areas of education, infrastructure, entrepreneurship, immigration, trade and research). This policy should support business leaders as they develop organisational models and approaches leading to 'inclusive prosperity' and foster 'more and better research on the economic and social implications of the digital revolution'.

KEY CONCEPT: COMPLEMENTARITY

An inclusive robot agenda should encompass more than providing training in 21st century skills, social measures for those who may lose their jobs to robots, and a legislative framework for self-driving cars, drones, and other applications. The key concept in all this is *complementarity*, i.e. having people and robotics work together and grow more productive as a result, instead of letting robots take over as many jobs as possible. David Autor, a leading economist in the area of automation, believes that journalists and even experts tend to exaggerate the extent to which machines can and do actually replace human labour. They pay too little attention to the close complementarity between automation and labour, which can improve productivity and incomes and increase the demand for labour (Autor 2015).

Robotics will indeed take over various human jobs in the future, but most experts believe that, for the time being, the main focus will be on complementarity (Autor 2014, 2015; Brynjolfsson and McAfee 2014; Cowen 2013; Ford 2015). In most cases, human labour is not replaced entirely by new IT applications and robotics. Instead, the latter serve as aids, with the most important decisions and judgements still falling to human beings (Carr 2015).[4] Aeroplanes are a good example. They are technological wonders that incorporate considerable robotics, but having them fly without pilots would be neither safe nor desirable (most people would refuse to board a plane without a human pilot). Boeing anticipates the worldwide demand for new pilots and technicians to reach 1.2 million over the next twenty years (*Robotenomics* 2015). Complementarity is also a useful aim because man-machine cooperation leads to the biggest productivity gains, according to Freeman (2015). Brynjolfsson believes that government should encourage businesses and entrepreneurs and actively promote human labour. 'People are too passive. We control our own destiny. Not the machines' (*Vrij Nederland* 2015). Salomon's review of research shows that when humans and robots work together, the economy wins.

One way to promote complementarity is to develop applications in a process of co-creation, with technicians and developers working with potential users and customers from the very start of the development process. While there is a strong inclination to leave technology to the experts, Carr (2015) believes that doing so results in a *technology-first approach*. Carr is an advocate of *human-centred automation*, which combines the strengths of humans and machines.

Based on this idea, the four topics discussed below would in any event be important items on a robot agenda aiming to promote inclusiveness in our roboticised society of the future.

I Invest in robots with a view to co-creation

Robotisation creates opportunities for economic growth and productivity gains at a time when growth can no longer be assumed (see also WRR 2013). This is an area of opportunity for the Netherlands. Martijn Wisse (2015) indicates that government can (and should) play a role in solving coordination and collective action problems by helping investors and researchers – who may have trouble obtaining funding – find and connect with one another. That is, for example, the case in the home care sector (see case 'Waiting for Alice: Technology in home care', Kremer 2015). The responsibilities are spread so thin (between competing home care organisations, municipal authorities, and insurers) that investment is notable by its absence. To make the roboticised society a reality and find a place for Dutch businesses and inventions in that society, we must welcome robotisation and invest in cooperative partnerships.

We must pay special attention to promoting co-creation by involving developers, producers and users, but also the people who will be working with the applications. 'The next wave in open innovation will require embracing co-creation of solutions together with leading customers like cities or healthcare providers,' says Henk van Houten, General Manager at Philips Research (Van Houten 2015).
Co-creation is important for both workers and users. In the home care sector, we often see technicians developing products that people actually do not need simply because they are technically feasible. That is why the process of technological development should start by looking closely at what people really want.

Governments can set a good example, as major contractors and investors at local level in the fields of education and health care and as employers of a large workforce. In their essays, Kees Marges (2015) and Anna Salomons (2015) both explain how to actively involve employees and unions and why that is necessary. Recently, the Dutch Government asked the Social and Economic Council of the Netherlands to advise it on the consequences of new technologies like robotisation, and its advisory report is likely to address this aspect as well.

II Teaching and learning focusing on complementarity

The answer to job polarisation, digitisation and robotics that is most commonly heard and argued is that we need to train more people at higher levels. That may well be true, but it is not enough. After all, in the future machines will probably be able to take over much of the work of educated professionals as well. It is no longer possible to become smarter than a computer. A better strategy would be to train people *better*, not more – at all levels. That means more *specialised* training.
The key question then is what people need to learn (both in school and throughout their working lives) to prepare for the roboticised society.

Focusing purely on technical skills is not the answer either. In line with our proposition that we must seek complementarity between humans and machines, Davenport and Kirby (2015) and Autor (2014, 2015) observe that many of the valuable activities of our 'wetware' (our brains) is not codifiable. Tacit knowledge and interpersonal and intrapersonal intelligence (knowing how to work well with others on the one hand and knowing your own interests, aims and strengths on the other) allow people to work with machines to create value (Colvin 2015).
Frey (University of Oxford) says in this study that 'Good education, then, does not mean acquiring hard-tech skills alone, but more importantly learning how to solve problems creatively and how to deal with, persuade and negotiate with others' (cited in Thomas 2015). It will be a very long time before robots have social skills,

if indeed they ever will, and technological and organisational changes have made human skills more important than ever (see also Borghans et al. 2014; Deming 2015). This finding has implications for how we approach lifelong learning and for school curricula. Instead of asking which jobs robots will do in the future, a better strategy is to ask what are the activities that only humans are capable of doing – Brynjolfsson (*Vrij Nederland* 2015) lists those involving creativity, interpersonal skills and physical dexterity – and what are the activities that we humans will simply insist be performed by other humans, even if computers could do them (Colvin 2015). Education would benefit if it prepared itself for that.

Another important strategy is to actively support those who have lost their jobs to progressive digitisation and robotics (or are at risk of doing so) as they seek new work, for example by providing education and training. The Council's report on the learning economy (WRR 2013) emphasises the importance of lifelong learning. Van den Berge and Ter Weel (2015a) recommend training vouchers and tax breaks to be applied towards training for people who have lost their jobs (or run the risk of doing so). It is precisely because digitisation is largely affecting actual job tasks that it will be even more important in future to anticipate the elimination of a job by encouraging people to continue learning, both at work and in their spare time.

III Quality of work and ownership

One vital component of the quality of work is the extent to which workers exercise control over their work activities (Gallie 2013). In other words, do they feel they can take ownership over their work? When people exercise control over their duties and feel engaged in their work, both individual employees and employers benefit. By taking 'ownership', working people are more prepared to learn new skills and run less risk of stress and burnout, leading to lower absenteeism rates. In short, the general wellbeing of workers who take ownership of and exercise control over their work is better than those for whom this does not apply, and that has a positive knock-on effect on productivity (see also Salomons 2015; Gallie 2012, 2013; Schaufeli and Bakker 2013).[5]

One crucial question for the near future should therefore be, does robotisation increase or decrease this sense of 'ownership'? Two schools of thought arose in the 1950s with opposing theories in that regard (Gallie 2012). One argues that technology simplifies work, discouraging people's creativity and undermining their ability to initiate their own work activities. In other words, combining Taylor's scientific management with new technology leads to alienation and a decline in the quality of work. Skidelsky (2015) writes that digitisation may be making the work performed in the service sector more impersonal, with more top-down supervision and control. The other school of thought believes that technology is growing more refined all the time and that rising skill levels are allowing people to increasingly choose their own paths. In other words, the arrival of machines makes it possible for people to do their jobs better. There is evidence for this viewpoint as well, for example in the journal *New Technology, Work and Employment,* which often presents case studies.

New technology, robotics and AI can therefore have both a positive and a negative impact on the quality of work. At the moment, however, we know little about the consequences of robots and other machines for 'ownership' (for the legal dimension, see 'The robot, from slave to master', Popma 2015). It is important for our inclusive robot agenda to address this topic in order to ensure that 'control over one's work' is given the necessary attention. In the first instance, that obliges us to collect more data and to monitor the impact of robotisation on people's ownership over their work (once again across all skill levels). Scientists and researchers have a role to play in this context, but so do government, labour and management.

IV New issues of inequality

While economic inequality is growing smaller *between* countries, income inequality *within* countries has increased in many places around the world in recent decades (Kremer et al. 2014). The 'labour share' of national income fell across much of the world, whereas the 'capital share' grew (Karabarbounis and Neiman 2013).
In addition, many countries are experiencing a growing income disparity between workers. As we saw earlier, the Rathenau Institute and the Netherlands Bureau for Economic Policy Analysis have both drawn attention to the potential unequal distribution of the benefits of digitisation and robotics in the Netherlands (Van Est and Kool 2015; Van den Berge and Ter Weel 2015a). The issue has also generated a great deal of interest internationally (see Kool and van Est 2015; Van den Berge en Ter Weel 2015a; Freeman 2015; Brynjolfsson and McAfee 2014; Ford 2015; Krugman 2012; Rodrik 2015; Summers 2015; Toyama 2015; Wolf 2015).

Brynjolfsson and McAfee (2015) propose that automation and digitisation may 'rearrange the rewards for skills, talent and luck. It is not hard to see how this would lead to an even greater concentration of wealth and, with it, power'.
They suggest creating a 'robot dividend' that would allow everyone to partake of the financial benefits of robots, similar to the Alaska Permanent Fund.[6] Richard Freeman (2015) addresses the income distribution issue and makes suggestions for how we can achieve greater income equality. For example, he advocates giving workers ownership of capital. Harvard economist Dani Rodrik (2015) proposes setting up public venture funds that would own shares in new technologies and pay out a 'social dividend' from the profits to supplement people's earned income.
Given all the warnings and debates, it is important to investigate and keep close track of the distribution of incomes and capital in the roboticised society, and to study proposals and recommendations in this regard. Politicians can then take evidence-based measures where necessary.

The argument that robots will be assuming a considerable share of the work is often put forward to justify the introduction of a basic income (Brynjolfsson and McAfee 2014; Ford 2015). The analysis given in this chapter presumes, however, that that will not happen in the foreseeable future. In addition, many people actually want to work, not only to earn an income but for reasons of self-actualisation (Gallie 2013), another reason to support complementarity and making and keeping work appealing and attractive. Arguments advocating a basic income do not, we believe, currently include fear of the consequences of progressive digitisation and robotics.

There will, however, be those who cannot keep up, who fall between two stools, who need extra help transitioning to a different type of work, or who cannot earn enough money to live on. That is why policymakers need to create a portfolio of measures that will help and support people where necessary. That was also the case during the previous transition (to ICT, from the 1970s onwards), in which public support – in the form of working time reduction schemes, training, early retirement and other policies – was offered (Van Est and Kool 2015; see also Marges' essay on the Port of Rotterdam in *De robot de baas*). It is very likely that dedicated policy measures will be required again in future, subject to the idea that 'one size fits none'. Precisely what that portfolio of measures will contain should also be part of an inclusive robot agenda.

1.5 CONCLUSION

Robotisation creates opportunities for economic growth and productivity gains at a time when growth can no longer be assumed. There is no doubt that progressive digitisation and robotics will eliminate some jobs and change others, but commentators sometimes exaggerate the scale of this transition and the speed at which it will occur. In addition, we cannot predict which new jobs and activities will be created by new technologies. People continue to master the robot in many respects: much of human activity is far from being codifiable or routinisable and there are many things that only people can do, or that we insist that people do. That is what we must focus on in order to ensure that *everyone* has a place and a role in the roboticised society of the future, because it will not happen on its own.

We therefore advocate an inclusive robot agenda for governments, employers and employees, their representative organisations, researchers and other stakeholders that will help us master robots in a variety of different ways:
- by emphasising co-creation in robotics development;
- by focusing on complementarity and by appreciating and nurturing human skills in education;

- by exercising control over our work and paying close attention to the quality of work;
- by keeping close track of the impact of robots and other machines on the distribution of income and capital in order to correct inequalities where necessary.

NOTES

1 Many thanks to Hella Hueck, Anna Salomons (Utrecht University), Martijn Wisse (Delft University of Technology) and the WRR Council and staff for reading and commenting on earlier versions of this essay.

2 But we cannot measure that yet, or only to a certain extent, because the instruments we use to determine the growth and productivity rate have not been adapted to today's economy (Coyle 2014). The problem also comes down to the limitations of GDP as an indicator of economic robustness (Hueck and Went 2015; WRR 2013).

3 'Skill-biased technical change is a shift in the production technology that favours skilled over unskilled labour by increasing its relative productivity and, therefore, its relative demand' (*New Pelgrave Dictionary of Economics*).

4 This keys into the fact that computers can 'substitute for workers in performing routine, codifiable tasks while amplifying the comparative advantage of workers in supplying problem-solving skills, adaptability and creativity' (Autor 2015).

5 There has been a considerable amount of international research in recent years regarding the relationship between employee wellbeing and their performance. In its 2010 report on the subject, the World Economic Forum found that the output of employees who felt happy at work was up to 12% higher than otherwise, and that workers who had jobs in which they felt respected and listened to were sick less often and worked harder than those who did not (Davies 2015: 108).

6 'The state of provides a possible template: courtesy of the Alaska Permanent Fund, which was established in 1976, the great majority of the state's residents receive a non-trivial amount of capital income every year. A portion of the state's oil revenue is deposited into the fund, and each October, a dividend from it is given to each eligible resident. In 2014, this dividend was $1,884' (Brynjolfsson and McAfee 2015).

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THE NETHERLANDS SCIENTIFIC COUNCIL FOR GOVERNMENT POLICY

Mastering the Robot

Every day, it seems, the media report that 'the robots' are coming. And with robotics becoming faster and smarter all the time, the critics fear massive job losses. But is that likely to happen?

In this publication, technology experts, economists and other researchers consider what robotisation and digitisation mean for the future of work. Some jobs will disappear, new jobs will be created, and the nature of much of our work will change. But robotisation takes much more time and effort than many assume.

Government, researchers, employers and employees, and their representative organisations can also influence the way in which technology is developed and applied. We can master the robot by developing an inclusive agenda that stresses complementarity between humans and machines and focuses on co-creation, training, the quality of work, and new issues of inequality.