

 Open access • Journal Article • DOI:10.1504/IJTM.2017.083074

Futures of robotics. Human work in digital transformation — [Source link](#)

Jari Kaivo-oja, Steffen Roth, Leo Westerlund

Institutions: University of Turku

Published on: 24 Mar 2017 - International Journal of Technology Management (Inderscience Publishers (IEL))

Topics: Futures studies, European union, Digital transformation, Robotics and Technology roadmap

Related papers:

- [Futures of Robotics. Human Work in Digital Transformation](#)
- [The Technological Future of Work and Robotics](#)
- [Digital Transformation Strategies](#)
- [Mapping the Evolution of the Robotics Industry: A cross country comparison](#)
- [The State of Industrial Robotics: Emerging Technologies, Challenges, and Key Research Directions](#)

Share this paper:    

View more about this paper here: <https://typeset.io/papers/futures-of-robotics-human-work-in-digital-transformation-2di20r9je7>

Kaivo-oja, Jari; Roth, Steffen; Westerlund, Leo

Article — Accepted Manuscript (Postprint)

Futures of robotics. Human work in digital transformation

International Journal of Technology Management

Suggested Citation: Kaivo-oja, Jari; Roth, Steffen; Westerlund, Leo (2016) : Futures of robotics. Human work in digital transformation, International Journal of Technology Management, ISSN 1741-5276, Inderscience, Olney, Vol. 73, Iss. 4, pp. 176-205, <https://doi.org/10.1504/IJTM.2017.083074>

This Version is available at:

<http://hdl.handle.net/10419/140877>

Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.

Futures of robotics. Human work in digital transformation

Jari Kaivo-oja*

Turku School of Economics,
Rehtorinpellonkatu 3, 20500 Turku, Finland
Email: jari.kaivo-oja@utu.fi
*Corresponding author

Steffen Roth

ESC Rennes School of Business,
2 Rue Robert d'Abrissel, 35000 Rennes, France
Email: steffen.roth@esc-rennes.com

Leo Westerlund

Aie Ltd., Näätätie 3, 00800 Helsinki, Finland
Email: leo@aie.fi

Abstract: In this article we discuss the futures of work and robotics. We evaluate key future trends in the field of robotics and analyse different scenarios regarding the futures of human beings and work life. Subsequently, we present a roadmap of robotics, which covers key aspects of industrial and service robotics, discuss technology foresight insights and inter-linkages to robotics, and identify three critical technology roadmaps: the technological future of robotics, digitalisation and ICT technologies. Finally, we analyse economic, social, and political key challenges of the digital transformation of work and labour policy in the European Union in general and against the backdrop of the European robotics strategy in particular.

Keywords: robotics; work; digital transformation; foresight; futures studies.

Reference to this paper should be made as follows: Kaivo-oja, J., Roth, S. and Westerlund, L. (xxxx) 'Futures of robotics. Human work in digital transformation', *Int. J. Technology Management*, Vol. X, No. Y, pp.xxx-xxx.

Biographical notes: Jari Kaivo-oja is one of the leading foresight experts and innovation management researchers in the Nordic countries. He has worked in numerous EU Commission projects in the 6th and 7th framework programs. He is Research Director at the Finland Futures Research Centre of Turku School of Economics as well as Adjunct Professor at the University of Helsinki and at the University of Lapland. He has worked for the European Commission, the European Foundation, the Nordic Innovation Center (NIC), the Finnish Funding Agency for Technology and Innovation (TEKES), EUROSTAT, RAND Europe, and for the European Parliament. Currently, he cooperates with the Chinese Academy of Social Sciences (CASS) in the field of global energy and climate policy.

Steffen Roth is a tenured Assistant Professor of Management and Organization at the ESC Rennes School of Business, an Affiliate Professor at the Yerevan State University Department of Sociology, and a Visiting Professor at the International University of Rabat School of Business. He was awarded a PhD in Management from the Chemnitz University of Technology, and received another PhD in Organizational Sociology at the University of Geneva. He was a Visiting Professor at the University of Cagliari, the Copenhagen Business School, and the Yerevan State University. His research fields include organisation theory, functional differentiation, next societies, ideation and crowdsourcing, and culturomics.

Leo Westerlund is a writer, translator, interpreter, performing artist, and thinker. His main interests lie in the societal dimensions of (technological) development, languages, language philosophy, sound environments, and music. He has actively participated in research projects on service design such as in the INTERREG IV A project ServiceD and has been responsible for Finnish-English translations and the linguistic aspects in this context. In general, he is described as a man with an insatiable appetite for information and knowledge about the world and the people in it.

1 Introduction

In this article we shall discuss the futures of work and robotics. The key idea is to evaluate current trends of European work life and present some diagnoses and prognoses as well as a policy prescription for European robotics strategy with special attention to human welfare as well as health and safety issues. Focus of European economic and social policy has been on ‘jobs and growth’ and ‘social inclusiveness’. These two policy priorities remain relevant but many ongoing changes and transitions in the European economy and civil society require more attention. These include developments regarding robotics and artificial intelligence (AI).

European robotics strategy is explained in many ways in the Robotics 2020 report, its summary outlining current developments in the following way:

“Robotics Technology will become dominant in the coming decade. It will influence every aspect of work and home. Robotics has the potential to transform lives and work practices, raise efficiency and safety levels, provide enhanced levels of service and create jobs. Its impact will grow over time as will the interaction between robots and people.”

We want to underline that robotics is not only a matter of science, technology and innovation policy but also a social and health issue. As US Robotics outlines, moving from internet to robotics will include many social and cultural challenges. Achieving open innovation and creating a strong component marketplace are important strategic objectives for European policy-makers. Many essential aspects of robotics and AI developments include great social challenges and health and safety risks, which require political attention. European societies are currently facing important challenges. Robotics can be an integral part of wider solutions to these challenges, but also entails important ethical, legal, and societal (ELS) impacts. Addressing these impacts needs to go hand in hand with the deployment of technology. In the EU Robotics strategy, a key issue is to underline that early awareness of the inevitable ELS issues will allow timely legislative

action and societal interaction. Of equal importance is the need to ensure industrial and service designers of robot systems are aware of these issues and provided with guidance to create compliant and ethical systems. Addressing the ELS issues will help support the development of new markets by building confidence.

This article includes the following sections, each elaborating different key aspects of robotics and future of work life. Section 2 evaluates key future trends in the field of robotics. Especially futuristic insights to modern ubiquitous knowledge society are provided. Section 3 includes various scenarios regarding the futures of human beings and work life. This section includes evidence-based insights concerning key changes in work life and human welfare. Section 4 presents a roadmap of robotics, which covers key aspects of industrial and service robotics. Section 5 provides some technology foresight insights and inter-linkages to robotics. There are three critical technology roadmaps

- 1 the technological future of robotics
- 2 digitalisation
- 3 ICT technologies.

Section 6 identifies the key challenges of future work life and labour policy in the European Union: economic, social, and political. Section 7 informs readers about some important strategic projects of the European Union, especially about the European robotics strategy. A summary is outlined in Section 8.

2 Key future trends in robotics: futuristic insights to modern ubiquitous knowledge society

2.1 New phase of European knowledge society policy

In the European Union the robotics Public Private Partnership (PPP) is the agent for implementing the robotics strategy. Its purpose is to connect the science base to the marketplace, a connection that ultimately benefits the society as a whole. Its vision is to attain a global leading position in the robotics market across all domains.

The ongoing societal transformation takes multiple forms. Different aspects of this development have been given a multitude of names, depending on the viewpoint and focus of attention; *information society* (see, e.g., Machlup, 1962; Porat, 1977), *knowledge society* (see, e.g., Stehr, 2002), *service society* (see Malaska, 2003) *super-industrial society* (Toffler, 1970), *post-industrial society* (see Touraine, 1971; Bell, 1974), *network society* (see Castells, 1996) *participatory economy* (see Hahnel, 2005), *telematic society* (see Nora and Minc, 1981), and *ubiquitous society* (see Greenfield, 2006; Stappers, 2006) have been used, alongside an array of other more or less descriptive key words, to highlight the ways in which our societies have changed and continue to change. Albeit each of these concepts describes a slightly different sphere of the society or a different point along a chronological line of development, the terms are definitely not mutually exclusive.

Discussing the technological and business aspects of this development, we are faced with yet another array of concepts: *everyware* (Greenfield, 2006), *anywhere revolution* (Green, 2010), *Web 1.0*, *Web 2.0* (see, e.g., O'Reilly, 2009; Gehl, 2011), *Web 3.0* (see

Berners-Lee et al., 2009; Antoniou and van Harmelen, 2008), *Web 4.0* (see, e.g., Kiehne, 2012), pervasive computing (see Hansmann et al., 2004), *ambient intelligence* (see Weber et al., 2005), *Semantic Web* (see, e.g., Berners-Lee et al., 2009), and *ubiquitous computing* (see, e.g., Weiser, 1991) belong to the relevant vocabulary. Even further, discussing the objects of the ubiquitous world brings forth another list of terms: *the Internet of Things* (see Ashton, 2009), *things that think*, *computer haptics* (see, e.g., Massie, 1993), and *physical computing* (see O’Sullivan and Igoe, 2004), to name but a few.

Ronzani (2007) has done interesting research into the usage of the terms ‘ubiquitous computing’, ‘pervasive computing’, and ‘ambient intelligence’ in mass media. His study “suggests that by and large the three concepts are described by the same attributes” [Ronzani, (2007), p.9].

2.2 *Information society and ubiquitous knowledge society*

In general we can claim that we have been moving from information society to knowledge society and from knowledge society to ubiquitous knowledge society. In ubiquitous society the role of smart and autonomous machines will be a key issue. Technology waves such as digitalisation, information and communication technology (ICT), and robotics are crucial elements of the new ubiquitous society.

Wikipedia defines information society as a “society where the creation, distribution, diffusion, use, integration and manipulation of information is a significant economic, political, and cultural activity.” On first glance, this definition seems sound, but if we look at the past development of human societies and civilisations this has been the norm: the exchange of ideas and technology, i.e. exchange of information through cooperation and competition has always been the driving force of the humanity as a whole (see McNeill and McNeill, 2003). This definition does not seem to provide a sound basis for comparison with other key terms. Indeed, in the contemporary discussion the term is mostly applied to the manner in which technologies have impacted society and culture.

Network society, on the other hand, has been used to describe a society that increasingly organises its inner relationships in media networks that by and by replace or augment the social networks based on face-to-face communication (van Dijk, 2006) or as Manuel Castells put it in an interview (Kreisler, 2001), the network society is “a society where the key social structures and activities are organized around electronically processed information networks.” Even though van Dijk (2006) and Castells (1996) differ in their approaches to what counts as the basic unit of modern society – for Castells it is the network, for van Dijk the individual – their definitions of network society provide a framework that enables even casual readers to understand what it means.

It is probable that robotics will be in many ways linked to the internet of things (IoT) in the future. Thus, *robotics meets Internet of Things and this linking process changes our understanding of the ‘old’ network society*. In this process ubiquitous robots are going to be more and more common. Ubiquitous robot is a term used in an analogous way to ubiquitous computing. Software products useful for integrating robotic technologies with technologies from the fields of ubiquitous and pervasive computing, sensor networks, and ambient intelligence are key elements of change. Emergence of mobile phones, wearable computers, and ubiquitous computing predicts human beings will live in a ubiquitous world in which all devices (including robots) are fully networked.

Since the early stages of the first industrial revolution, economic history has been characterised by an increasing dematerialisation of individual human work and immaterialisation of consumption (more demand for services). The industrial revolution was made possible by the substitution of manual labour with machines, then by the development of services and, finally, the advent of the virtual during the digital revolution. Developments in the field of robotics follow a similar logic. The contemporary world is filled with data and information, neither of which is sufficient enough to create any great value without the knowledge of how to apply said data and information. In other words ideas, inventions and innovations depend on the human knowledge base.

This article leans towards a broader definition of knowledge society because a limited focus on the economics of knowledge is better described as the knowledge economy, which can be viewed as the economic counterpart of information society.

According to UNESCO's (2005, p.27) report:

“Knowledge societies are about capabilities to identify, produce, process, transform, disseminate and use information to build and apply knowledge for human development. They require an empowering social vision that encompasses plurality, inclusion, solidarity and participation”.

However, it is wise to point out that the ‘broader social, ethical and political dimensions’ entailed by UNESCO are all, at least to some extent, dependent on the economy and the ways in which we do business.

UNESCO has emphasised in many contexts that the concept of knowledge society is more all-embracing and more conducive to empowerment than the concepts of ‘technology’ and ‘connectivity’, which often dominate social and political discussion on information/knowledge society. International debate on technology and connectivity emphasises infrastructures and governance of the network planet. Technology and connectivity should not be viewed as ends in themselves. The global information society is meaningful only if it favours the development of knowledge societies and sets itself the goal of ‘tending towards human development based on human rights’. This kind of human emphasis is good to remember also in discussions about robotics. For UNESCO (2005, p.27), the construction of knowledge societies “opens the way to humanization of the process of globalization”.

In this respect, it is perhaps also relevant to refer to the increasingly knowledge-driven nature of business; one topical theme being knowledge-intensive businesses (Toivonen, 2004; Strambach, 2008). Key processes of knowledge-intensive business are codification, abstraction, and diffusion. Knowledge assets are created in these processes. Embodied knowledge has a very low level, narrative knowledge has a higher level, and finally, formal knowledge has the highest possible level of codification and abstraction (Boisot, 1995, 1998). Embodied, narrative, and formal knowledge can be stored, exchanged, and sold in various markets and businesses.

It can be stated that the prerequisites of knowledge society include:

- 1 the availability of information and networks
- 2 the ability to exploit information
- 3 respect for different ways of knowing.

The emergence of robotics r/evolution deepens these developments.

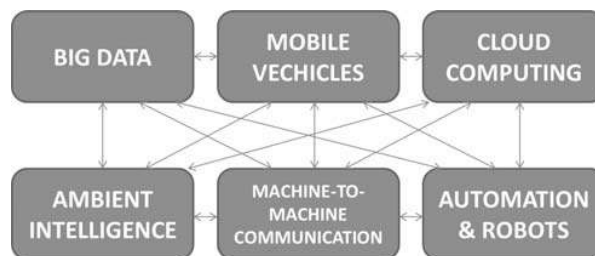
Ubiquitous society is a term describing a world where computing is present everywhere simultaneously, where it exists everywhere at the same time. In this context computing does not necessarily equal computers as we know them. In other words, the ubiquitous society is a future where computing is everywhere but nowhere in particular.

The possibilities and risks related to the ubiquitous revolution can be attributed to (almost) every sphere of human activity. However, it is easy to underline two main questions dominating the contemporary debate: future business models and the relationship between the individual and the society at large.

In the ubiquitous society, things are connected. Not only are networks, markets, and crowds connected (Roth et al., 2013), but human beings, machines, robots, and media are also going to be interconnected in complex ways. Ubiquitous society includes elements of a trans-mediated reality. It is noteworthy that ubiquitous computing and the ubiquitous society takes, at least technologically speaking, many forms. Greenfield (2006, p.15) explains: “The many forms of ubiquitous computing are indistinguishable from the user’s perspective and will appear to a user as aspects of a single paradigm” (...). He goes on and explains that it “appears not merely in more places than personal computing does, but in more different kinds of places, at a greater variety of scales” (ibid., p.46). Hunter (2002, p.xxii) paints a scarier picture of ubiquitous computing: “[W]e’ll be living in a man-made environment of intelligent machines that are capable of seeing, hearing, and understanding most of what we do. Everything’s recorded. Nothing’s forgotten.” Ubiquitous computing and ubirobots will drastically change our societies – that much is certain. We should not let technological development dictate this development. Instead, we should concentrate on building such a knowledge society that is capable of producing a preferable ubiquitous tomorrow instead of a dystopian one.

Figure 1 visualises complex systemic elements of ubiquitous r/evolution. These elements are in close technical interaction. Thinking carefully about this Figure 1 reveals many uncertainties and risks of ubiquitous r/evolution. Robotics and AI automation are key aspects of the risks.

Figure 1 Complex systemic elements of ubiquitous r/evolution



The capabilities of many digital devices are strongly linked to Moore’s law: sensors, processing speed, memory capacity, and even the number and size of pixels in digital cameras. All of these are improving at roughly exponential rates. The speed of developments and new tech applications is amazing. Ubiquitous r/evolution involves a lot of challenges. High speed gigabit switches are already up and running. Cloud services will continue to evolve, increasing the greening of IT technology and the accessibility of

applications, which in turn strengthens the democracy of the market economy in many countries.

The emergence of new pervasive computing terminals, new computing solutions in cars and mobile services, new navigation positioning apps used in a variety of new ways are changing our way of life. Care robots, surgical robots, robot cleaners, and many other new robotic applications are a growing segment of the consumer market (Bowonder and Miyake, 1994, 2000; Sato et al., 1996), the blood vessels in 3D printing (Kaivo-oja et al., in press), and AI will be helpful for many professionals and occupations. Also engineers, doctors and lawyers can be helped by new technology and applications. New inventions of robotics and automation will be adopted in the field of military industries and security services. Future wars will be won with air, maritime and field robots. Technological advances and robotisation continue accelerating in many areas of human activities, at peace and in war.

Ubiquitous technologies affect fundamental human activities: labour, leisure, housing and transportation. We cannot find an area unaffected by this r/evolution. For this reason many countries, Japan a case in point, have already established ubiquitous strategies to secure their competitiveness and built a variety of technology platforms to ubiquitous applications.

Large quantitative changes give rise to qualitative changes, which are almost impossible to predict because of the complexity of the developments. High-speed computing systems have already created opportunities for faster, more reliable and more precise decision-making and action, whilst threats and risks stemming from this rapid development are identified. Is development perhaps too fast? Might the increasing speed of ubiquitous and other technological progress cause greater risks to the economy and society?

In the coming ubiquitous society, major problems might be connected to:

- 1 speed blindness
- 2 ill-considered decisions and, possibly
- 3 the fact that necessary decisions are not made at all.

We must still live in a society of bounded rationality, in spite of all smartness of new technologies, scientific breakthroughs and innovations.

2.3 Ubiquitous robotics and changes in our realities

Now both mundane and ubiquitous technology is gaining a variety of applications. In the ubiquitous world, people communicate:

- 1 with each other (man-man)
- 2 machines communicate with people (man-machine), but also
- 3 machines (including robots) communicate with each other (machine-to-machine)
- 4 communication between robots can be seen as an area of its own (robot-to-robot).

The media turns ubiquitous and uses more machines and robotics (media-machine, robots-media), and communicating with people (media-man).

This technological development in ways of communication changes our culture dramatically. We can talk about trans-media and hypermedia. The borderlines between the virtual and the real world become fuzzy as the ubiquitous r/evolution goes on. Ubiquitous technology r/evolution creates many open windows and business opportunities for start-up companies developing apps for smart media, smart vehicles and smart machines.

New tech apps are a very big opportunity for companies to renew society and to make life easier. New forms of digital media applications will change media culture drastically. Co-creation and crowd sourcing, as well as a number of consumer and citizen media activities will emerge as key challenges for the media, which often include quite conservative actors.

Development has not yet been brought to us by ‘power of the brain’ but the internet and computer networks provide us a huge amount of information, knowledge and culture, which is within everyone’s reach. Choros (2011) sees in his book *World Wide Mind. The Coming Integration of Humanity, Machines, and the Internet* that human activities, machines and the internet will integrate together in the future. According to Choros, ubiquitous global integration process leads to the creation of the global mind (worldwide mind).

In spite of cold logic and calculative decision-making we use computers for social communication, transactions, and online social community building. The threats of the past have changed: now we are afraid of losing our privacy and fear cyber criminals and cyber terrorists. We fear cyber conflicts and cyber wars, which, of course, are technological threats that should be eliminated by excellence, technical safety/security information and effective training. The ubiquitous society is very vulnerable, and this should be taken into account in the development of digital technologies and new web applications.

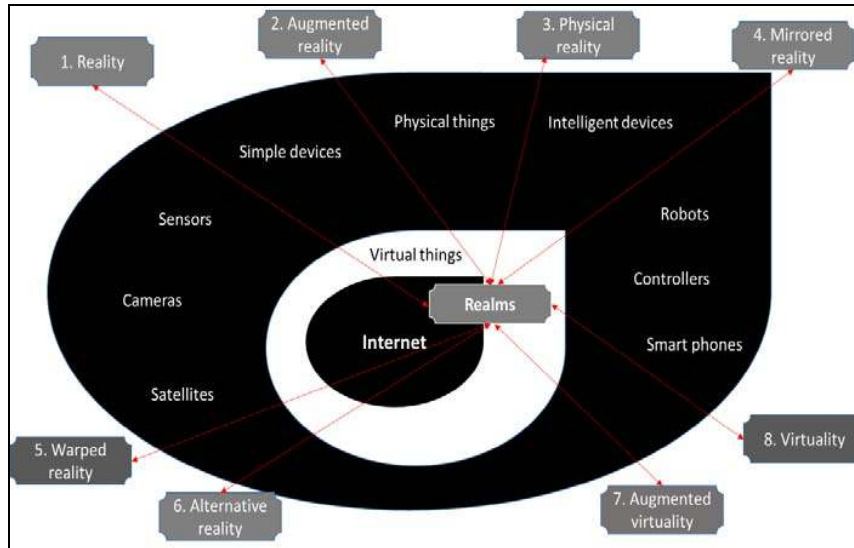
3 The future of work and robotics: a scenario analysis of human work

The IoT is a system that relies on autonomous communication of a group of physical objects. IoT is an emerging global internet-based information architecture facilitating the exchange of services and goods. Atzori et al. (2010, p.2793) evaluated that the main domains of IoT will be:

- 1 transportation and logistics
- 2 healthcare
- 3 smart environment (home, office and plant)
- 4 personal and social.

In Figure 2, key elements of IoT with key realms of multiverse are illustrated.

Figure 2 IoT, devices and realms of multiverse (see online version for colours)



Source: Modification from Chen and Hu (2013, p.161) and Pine and Korn (2011)

In Table 1, the realms of ubiquitous society are figured out. This entity is called the multiverse. Table 1 tells to us that leaders, managers, planners – people responsible for running business – must understand the fundamental nature of the three elements of reality: time, space and matter. The multiverse, not only the universe, calls for new service designs, architectures and business models. What is obvious is that managers must work in order to manage these realms of the ubiquitous society. Challenging issues of the ubiquitous society will be multidimensional scales of time, matter and reality. Currently the increasing importance of virtual reality is a particularly challenging issue. Robotics also deals with this aspect of virtuality (see Table 1).

Table 1 Realms in the ubiquitous society and in the multiverse

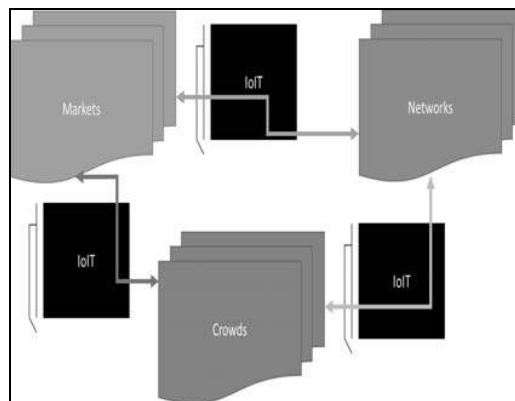
Variables				Realm
1	Time	Space	Matter	Reality
2	Time	Space	No-matter	Augmented reality
3	Time	No-space	Matter	Physical reality
4	Time	No-space	No-matter	Mirrored reality
5	No-time	Space	Matter	Warped reality
6	No-time	Space	no-matter	Alternative reality
7	No-time	No-space	Matter	Augmented reality
7	No-time	No-space	No-matter	Virtuality

Source: Pine and Korn (2011, p.17)

IoT applications are numerous, basically meaning smart things and systems such as smart homes, smart cities, smart industrial automation and smart services. IoT systems provide better productivity, efficiency and better quality to numerous service providers and industries. IoT is based on social, cultural and economic trust and associated trust management skills, which broadly speaking mean developed security services and antifragility operations. Critical issues of IoT security field are (Sicari et al., 2015; King and Raja, 2012): trusted platforms, low-complexity, encryption, access control, secure data, provenance, data confidentiality, authentication, identity management, and privacy enhancing technologies (PETs).

Security of IoT requires data confidentiality, privacy and trust. These security issues are managed by distributed intelligence, distributed systems, smart computing and communication identification systems (Sicari et al., 2015; King and Raja, 2012). Finally, in Figure 3 we have figured out the functioning pattern of markets, networks and crowds. IoT can be found between these key systems of global economy. There is probably a lot of potential for smartness between these systems. Data, information and knowledge about communication and interaction of these systems will be vital issues for the future of management.

Figure 3 The functioning pattern of markets, networks and crowds



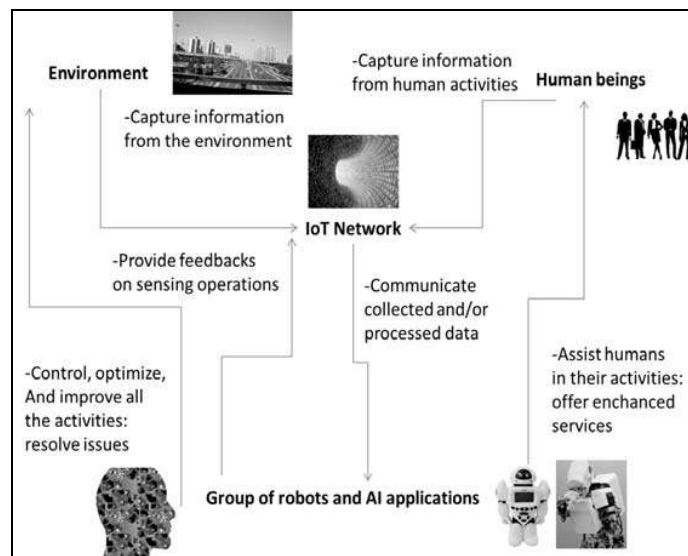
IoIT, the internet of intelligent things, as some experts emphasise smart Machine-to-Machine communication, provides much potential for crowd sourcing of markets and networks. IoIT also provides much potential for smart networking (between markets and networks and between various networks). We expect that one obvious consequence of IoIT will be a broader scope of deliberate democracy. Finally, the legal framework of IoT/IoIT is very vague or non-existing. Issues such as standardisation, service design architecture, service design models, data privacy and data security create management and governance problems, which are not totally solved within current service architectures. IoT has also become subject to power politics because of risks of cyber war, cyber terror and cyber criminality (see, e.g., Robinson et al., 2015).

Figure 4 presents a global reference scenario for IoT-aided robotics and AI applications. We can see that IoT will be central for the collection of big data. Big data will be collected from:

- 1 the environment
- 2 human beings
- 3 robots and AI applications.

Figure 4 describes the key elements of future management system. Robots and AI application can assist and help managers and leaders in many ways. Support for the existence of *hormetic effects* between resilience and adversity stems from a view of biological systems as generally *adapting for energetic efficiency* in adverse environments (Parsons, 1997, 2005). This entails that the continuing adaptation to our always changing environments constantly involves certain energy demands (McEwen and Wingfield, 2003). As our whole biology is built to deal with these demands in an optimally efficient way, exposure to mild stress may actually trigger an adaptive response that optimises our system’s overall energy efficiency by maximising our *stress resistance* (Parsons, 2005).

Figure 4 A global reference scenario for IoT aided robotics and AI application



Source: A modification of Grieco et al. (2014, p.34)

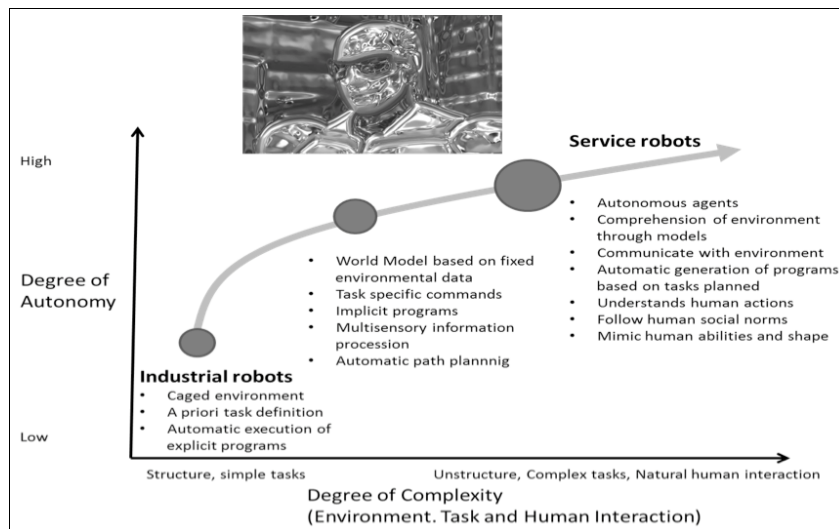
4 Framework of roadmap of robotics: from industrial robotics to service robotics

Between the 1960s and the 1990s, most robots and robotics in general were related to industrial applications. The key challenge was to rationalise production at manufacturing sites. Now robots are becoming ubiquitous, reaching exceptional capabilities and robustness. Service robots support, accompany and nurse humans. Robots will be helpers in healthcare and personal life. Service industries develop many new service robot applications. Service robots share the human environment and exhibit basic intelligent

behaviour to accomplish assigned tasks. We can expect that degree of autonomy and system complexity along with human-centred applications.

In the future service robotics will play a bigger role. Service robotics is an emerging application for human-centred technologies and the service economy. Recent studies imply that the rise of household and personal assistance robots forecast a human-robot collaborative society. In Figure 5, a three-phase model of robotics is presented. This model illustrates key phases of robotics.

Figure 5 Evolution of robotics



Notes: Current trends are leading towards more complex, more personalised and autonomous systems and robot services. This implies flexible systems that are able to perform tasks in an unconstrained, human centred environment.

Source: Haidegger et al. (2013, p.1216)

We can identify three classes in the field of service robotics.

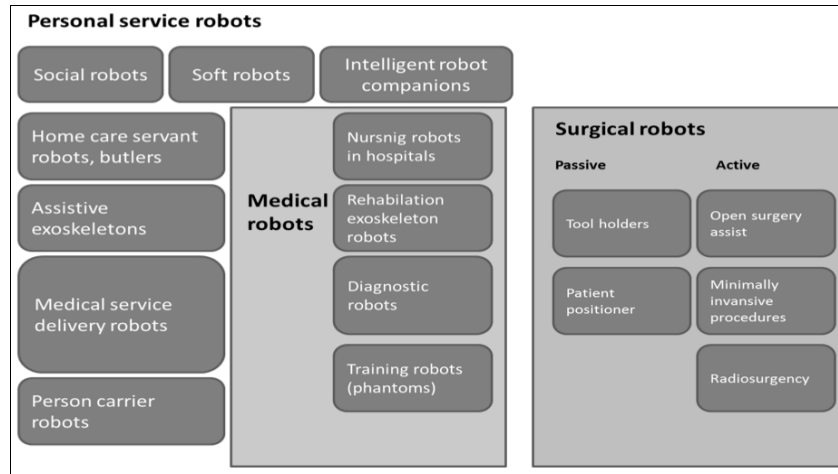
Class 1 Robots replace humans at work in dirty, hazardous environments and tedious operations.

Class 2 Robots operate closely with humans to alleviate incommmodity or to increase comfort, such as entertainment, assisting the elderly or carrying patients, etc.

Class 3 Robots operate humans, e.g., medical robots for diagnosis, surgery, treatment and rehabilitation.

In the field of service robotics, recent developments in medical and personal healthcare have been outstanding. In this specific field, the following robot applications can be identified (Figure 6).

Figure 6 Categories of medical/non-medical personal service robots



Source: Haidegger et al. (2013, p.1217)

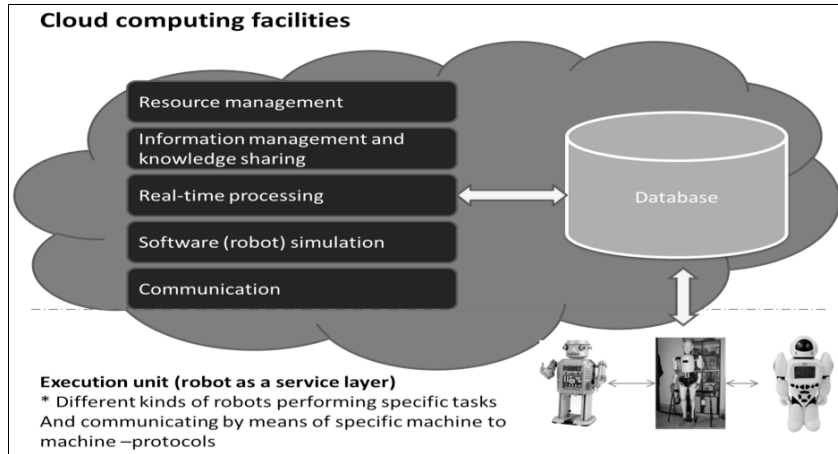
In other service industries similar kinds of ‘robot families’ will emerge during the next years and next decade. Technological transformation will bring robots as personal and social helpers to the European service economy. The ‘robot families’ will change European work life in many ways. Many innovative robotics developments will happen in urban and service economy contexts (see Lee et al., 2013).

5 Technology foresight insights and inter-linkages to robotics: three critical technology roadmaps, the technological future of robotics, digitalisation and ICT technologies

The number of devices involved in Machine-to-Machine communications is expected to steadily grow till 2020. In 2020, the number of smart objects able to talk to each other and to inter-operate with humans should be around 50 billion. This development will lead to the era of IoT. In the ongoing IoT (or IoIT) revolution, the growing diffusion of robots in many activities of everyday life makes IoT-aided robotics applications a tangible reality of our future. The interplay between robots and ‘things’ will probably help humans in many ways. Figure 7 visualises robotics based on cloud computing facilities.

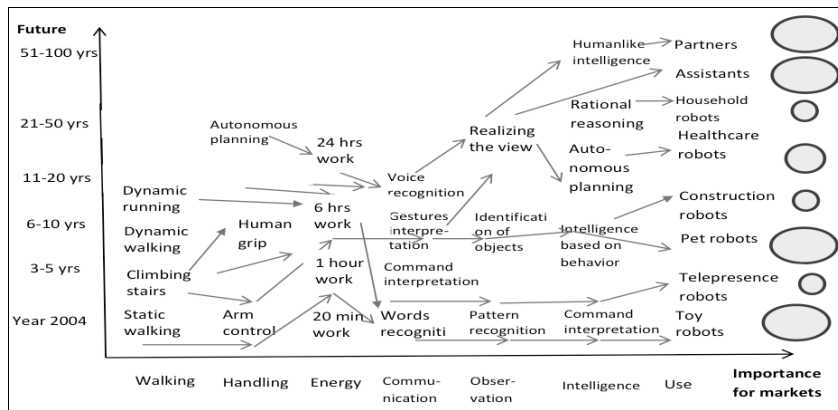
In Figure 8, a roadmap for robotics developments (Euron, 2004) is visualised. There will be partners, assistants, household robots, healthcare robots, construction robots, pet robots, telepresence robots and toy robots. These robot applications imitate human and animal behaviour. IoT and ubiquitous applications will enable these robot applications to communicate with each other.

Figure 7 Robotics based on cloud computing facilities



Source: Chibani et al. (2013)

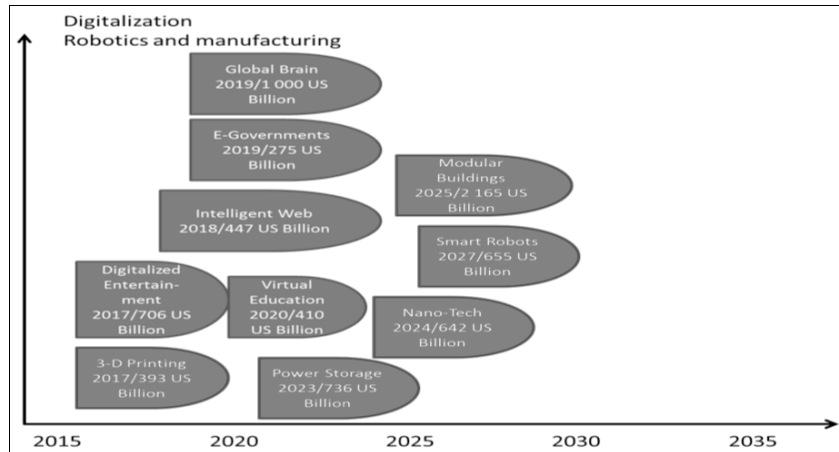
Figure 8 Roadmap for robotics developments



Source: Euron (2004)

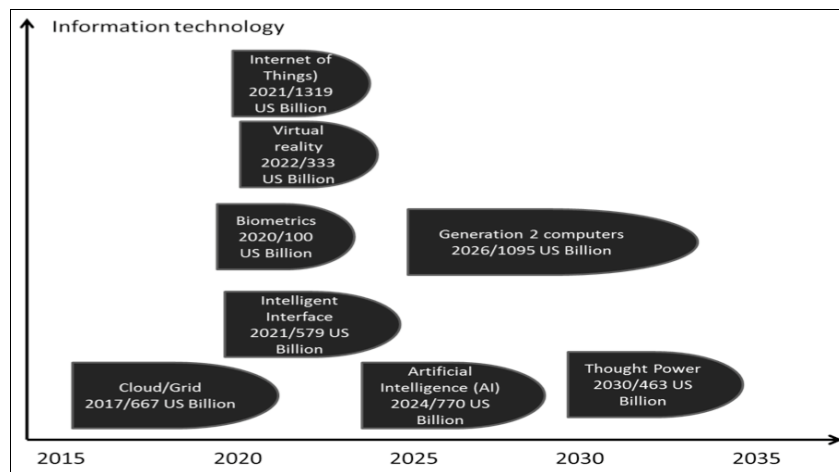
Figures 9 and 10 visualise roadmaps of digitalisation, robotics and manufacturing and information technology. These three technology waves are interlinked by IoT applications. What is for certain is that these technology waves change the ways people work and spend their time.

Figure 9 Technology roadmaps of digitalisation and robotics and manufacturing



Source: TechCast (2014)

Figure 10 Technology roadmap of information technology

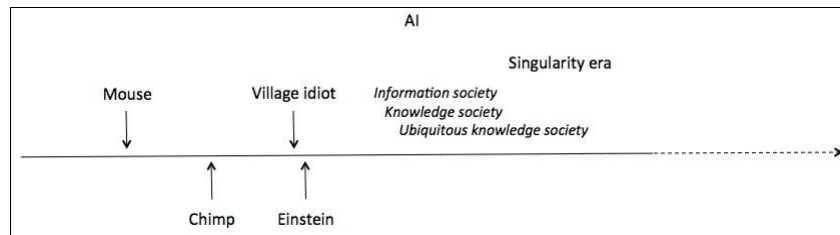


Source: TechCast (2014)

One of the key development aspects of robotics is linked to AI. Some authors talk about *the second machine age* (Brynjolfsson and McAfee, 2014) or *the age of superintelligence* (Bostrom, 2014). All these technological changes will lead to a smaller volume of routine work. Technical change increases the relative demand for highly educated workers while reducing demand for less educated workers whose jobs include routine cognitive and manual tasks.

In Figure 11, the intelligence explosion is placed on a time line. Key issue for the future is how the intelligence explosion is managed and how policy-makers make intelligence explosion survivable. Many systemic conflicts are likely to emerge and some technological developments include disruptive elements (see, e.g., McKinsey Global Institute, 2013).

Figure 11 The evolution of intelligence explosion



Source: Modification of Bostrom (2014, p.70)

6 Economic, social and political challenges of future work life and labour policy in European Union

6.1 Challenge of technological unemployment

Concern over technological unemployment is hardly a recent phenomenon. Throughout history the process of creative destruction that follows technological inventions has created enormous wealth, but also undesired disruptions. As stressed by Schumpeter (2013), it was not the lack of inventive ideas that set the boundaries for economic development, but rather powerful social and economic interests promoting the technological status quo. The idea of status quo is relevant also in the context of robotics and AI. The balance between job conservation and technological progress, therefore, reflects to a large extent the balance of power in society, and how gains from technological progress are distributed among citizens and stakeholders.

Technological developments have direct and indirect effects on the labour market. For example, fewer workers will be needed on average because industrial and service robots will replace many routine jobs and clearly definable tasks. In the future, the average employee is only the robot's deputy. The human role is to take care of planning, coding and occupying creativity and innovation to services and production. This change increases the need for creativity and creative change agents.

6.2 Work and singularity hypothesis

The extreme scenario of robotics has been presented by Kurzweil (1999, 2005) in the form of the singularity hypothesis, according to which computer intelligence will exceed human intelligence in the coming decades (see Figure 12). Kurzweil predicts that by 2029, technological progress has advanced to a stage where computers and ambient intelligence override human abilities. According to Kurzweil, this scientific and technological transition takes place around the year 2045 (Figure 13). This implies that

robots and other smart AI applications can do same things as normal people do. We can certainly disagree and be skeptical of Kurzweil's estimates. Maybe it is possible to find a Golden Rule between the extremes, between technological optimism and technological pessimism? In the history of futures studies and predictions Kurzweil has been quite a successful and visionary expert. From this viewpoint it may not be wise to adopt technological pessimism as regards the singularity hypothesis.

Figure 12 Singularity scenario and future of work

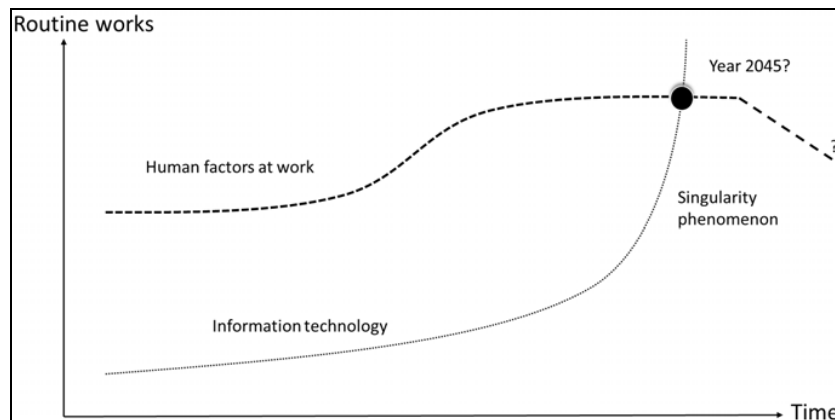
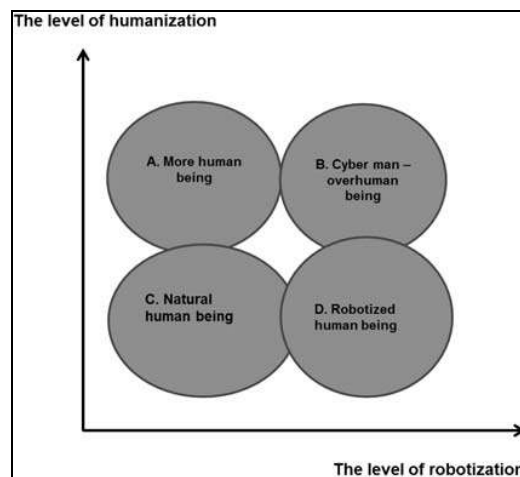


Figure 13 The future of human beings: the impact of robotics



What is certain, however, is that machines, computers and robots will be much more capable and flexible in the future. The question lies in the direction and speed of technological development and their meaning and significance for a man and humankind's fate? One way to deal with Kurzweil's scenario is obvious: robots and

avatars do not change our society in any way, but everything continues linearly as before. It's just a stage of technological development, just as well as the invention of the steam engine was during the industrial revolution. According to this paradigm we propose a hypothesis, which we may call the Ford's (2009) first hypothesis. The hypothesis is as follows: technology will never evolve to the point where average human being's work can be automated. In all circumstances and all times the economy creates and produces new jobs for people with average human knowledge and skills.

The role of routine work decreases in the singularity scenario. This means drastic changes in safety and health policies. The safety of routine work will not be such an important issue in the world of singularity. There would also be serious consequences for education policy and life-long learning if the singularity scenario became our future development path.

6.3 The future of human beings and work

In our scenario analysis, the analysis of human future is based on two development factors, humanisation and robotisation. These two drivers are relevant for the future of human beings as shown in Figure 13. Figure 13 presents four alternative scenarios of robotics affecting human development. Social and welfare policies should carefully consider the aspects and emphasise them in economic and robotics strategies. Private business interests might lead to the selection of a robotics substitution strategy, even though, from a broader socio-political point of view, the aspect of complementarity in robotics strategy should be emphasised. In this context, the aspects of value rationality should be considered carefully. This means that selecting a target rationale or approach is inadequate. The basic ethical question of whether one wants to allow robotics to preferably increase economic growth or well-being can prove to be very difficult for decision-makers.

Estimated from a global perspective it is clear that in the future everyone would have access to the same high level of technology, but the usability of technical solutions will have large regional differences. From this perspective, it is impossible to estimate that all the people would reach the cyber-people class. Probably we will find human beings in all the four scenario categories. This fact should be kept in mind when discussing robotics and its importance for the economy and the world of work. Today, the digital divide is a reality in the global context. The future of humankind and its cultural evolution will depend on how well we use technologies and take advantage of innovations and technical opportunities.

6.4 Trends in the workplace and work life

Freeman (2001), Freeman and Soete (1994) and Freeman and Loucã (2001) have identified seven qualitative trends in the workplace. Freeman speculated on the nature of future employment in the USA and Europe. He identified the following trends:

- increased employment of women in higher-paying jobs
- increase in average skills and age of workers
- global shift in world labour force towards nations that are today considered developing countries (BRICSA)

- shift in manufacturing employment to these developing countries
- continuing decline of manufacturing employment (but not necessarily output)
- growth of employment in healthcare and personal services
- nearly universal use of ICT at the workplace and in the markets.

The impacts of these trends on the work place and the future of work are not straightforward. Most likely we shall see great variety of work cultures and working conditions. In many European countries, unemployment has become a structural phenomenon resulting from fast technical progress and massive productivity increase. A divide is developing throughout Europe; a split between those who are still employed and those who are not. The ratio of those deprived of a job is increasing. Some scholars speak of a two-third society with two-thirds of people living in 'well-lit' conditions and one-third living on the 'dark side'. This is despite the irony of our societies still defining themselves as 'work societies' [Wilbert (1997), p.79]. In the long run many occupations and work places are at risk. According to an Oxford study, about 47% of total US employment is at risk (Frey and Osbornem, 2013). The impact of computerisation on labour market outcomes is well-established in academic literature, documenting the decline of employment in routine intensive occupations – i.e., occupations mainly consisting of tasks following well-defined procedures that can easily be performed by sophisticated algorithms. For example, work market studies by Charles et al. (2013) and Jaimovich and Siu (2012) emphasise that the ongoing decline in manufacturing employment and the disappearance of other routine jobs are causing the current low employment rates. If these trend estimates hold in the future, Europe will face a growing mass unemployment problem.

Futurist Viherä (2010) has estimated that human Motivation, Access to technological systems and created training Skills (MAS capabilities) are crucial to how well the benefits of technology can be realised in the work place (see Viherä, 1999). Growth of income inequality and the digital divide may also influence people's motivations, access to information networks and skills in sharply diverging ways. The differences of opportunities between rural and urban areas can be huge. The future of the internet is presented with very different estimates. The internet created and creates entirely new opportunities for open innovation and networking. On the other hand, regulation can change the future direction of development.

It would be a mistake to assume that the structures of society remain unchanged when future technological developments, globalisation and demographic changes occur. In this case decision-makers can find new opportunities and open windows. Most likely there will be new social movements and non-governmental organisations, whose importance will be on a completely different level than the influence of existing political organisations. In the field of futures research there has been much discussion about so-called micro-trends that are strongly associated with changes in the structure of societal trend factors. In structural factors of societies, the main future changes are (Gratton, 2010):

- *Re-organised families*: the traditional family will be re-organised and families rearranged. In the norm, families have previously been the core units of society. In post-industrialised countries there has been an increase in the number of reconstituted families – as well as single households and single-parent families.

- *Ultra-individualism*: people are becoming more self-aware as their reflection power increases. Ultra-individualism will become more common. When families organise themselves in a new way, and demographic structures change – the individuals' way of thinking about social relations will also change. Friendships are very important if not more so than family relations or kinship. Interpersonal depth and authenticity are key sources of human well-being. People make more and more bold decisions with regard to their own relationships, consequently non-functional backdrop relations are reduced.
- *The power of women*: the social role of women is changing. There will be an increase in the number of influential women, especially within the general level of education and in the labour market. Women will become more active, contributing politically and economically. Also, women will play a more prominent role in the management and leadership of companies and entrepreneurial businesses, with some joining the top echelons of the corporate elite. This change will affect the rules concerning working life but also life outside the workplace.
- *Re-defined roles of men*: men will have a more balanced role. Their attitudes and practices are changing, as is their position in the workplace and in society, due to the change in the status of women. They are looking for a new, more balanced role in society: their big issues being leisure time and time spent on relationships, the quality of relationships and career choices at different stages in their career. Debate on the role of men in the new social models will increase.
- *Trust*: trust is an important factor in the functioning of society. There is growing distrust towards institutions. Professor Francis Fukuyama introduced the concept of confidence into the wider international debate. He sees trust as a key issue of the political system and its credibility. People's faith and trust in big institutions and systems, policy initiatives and corporate responsibility have been seriously eroded over the last decades. Lack of confidence in leadership and policies does not remain without consequences in the social system.
- *Economic growth is not enough*: People's happiness and well-being are not unambiguously correlated with economic growth. There is a decline in happiness. In many societies, we can observe a negative correlation between welfare indicators and economic growth. This change has given rise to an animated discussion on economic growth and de-growth strategies (Roth, in press) as much as on downshifting in the work place.
- *Passive daydreamers*: passive leisure is increasing in many societies. People are spending more and more time reverting to a passive life-style, playing simple games, getting involved in more social activities, focusing on hobbies and watching TV. Passive time spent following the media is also increasing. Social media can change this trend to promote a more active lifestyle, but not everywhere. In order to involve citizens, it should provide a broad variety of services, and be truly socially oriented.

We can see many worrying trends in social and work life issues. Social upheaval and radicalisation of the youth is possible in many societies – especially in economies with high unemployment rates. Forecasts for the future show many disrupted families, people's condescending confidence in the basic institutions of society and loss of

happiness. On the other hand, we can see a number of promising opportunities to improve these worrying trends. We can focus ourselves on development and control. Policy-makers should require more responsible business practices and support social entrepreneurship.

6.5 The problem of structural unemployment

Intelligent machines are not a new thing for humankind. Yet the discussion of intelligent machines and social impacts of robotics and ubiquitous technology on the society and the economy has been passive, perhaps almost non-existent. It appears that the theme has been avoided even in the field of policy. Policy-makers like success stories of technology and science, but they do not like to critically analyse the side-effects of technological progress. Well-structured ideas and thoughts on how far robotised and automated society can be developed have been quite few.

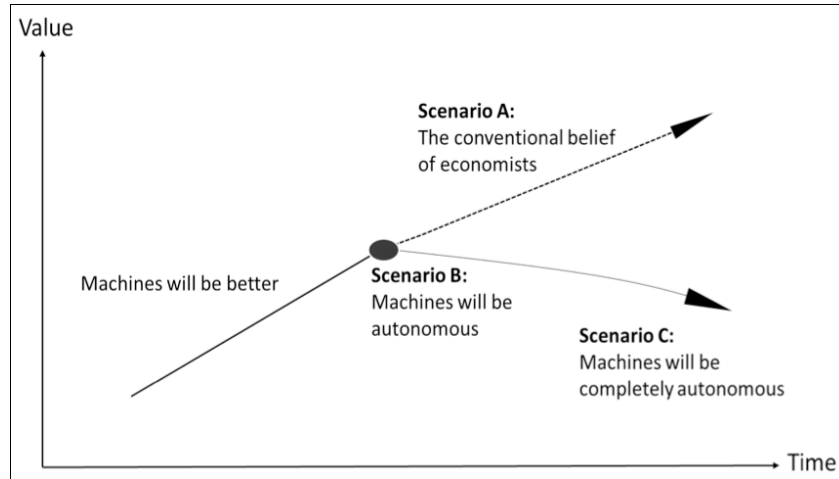
The hypothesis that developing technology could replace a large proportion of human labour and lead to permanent structural unemployment has been for a large part of economists an almost unthinkable idea. The few economists who have discussed the subject have simply been labelled old-fashioned machine haters. Further, the concept of neo-Luddite has been presented in such discussions. Automation and robotics are very sensitive topics in the field of economics.

For the representatives of conventional economics, technological progress has generally meant an increase in wealth and more jobs, at least in the long term. The new technology and scientific inventions being developed by engineers and scientists have generally been seen as very positive issues. Economists are enthusiastic about the new technology and novelties and they have been viewed to have high potential for societal progress and development. But the real impact of new technologies on employment, job destruction and the economy has been discussed very little. Many conventional economists believe that the market mechanism balances the problems in the long-run.

It has been typical to think that technological trajectories follow the logic of economic cycles and associated positive employment effects. A second key idea in economics has been that developing technology always increases people's well-being. In economics it is normal to think that the free market economy really takes care of things – at least with some time lag markets are in balance again (see scenarios of Figure 15). Wealth and progress, of which we enjoy today in the industrialised countries, would not have taken place without the capitalist logic. In the Western industrial era, technological development and market economy have evolved in parallel. Is this the case in the future? Should we really leave the discussion of robotisation and automation exclusively in the hidden arms of market forces?

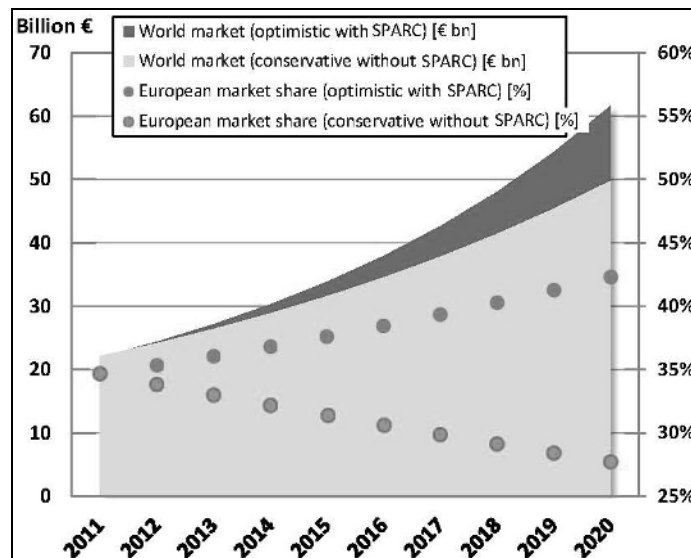
Still today, the key mechanism by which income and purchasing power is distributed to an individual is to have a job whether in a company or in the public sector. If it happens that at some point of time smart machines, and in particular, intelligent machines take care of most of the work, this kind of mechanism and thinking does not function anymore. Such a change is undoubtedly a great threat to the current economic system and to its financial foundation, and it should raise serious social reflections and broad public debate.

Figure 14 The potential effects of robotics: three alternative scenarios of work life



Source: Modification of Ford (2009)

Figure 15 Estimates on the world robotics market developments and reachable European market shares



Source: SPARC (2014b) Robotics in Europe Introduction [online] <http://www.sparc-robotics.net/robotics-in-europe/>

Society based on work ethos can no longer be taken for granted. How do people work in the future and receive income from their work? If they do not receive income from work, we need to think about how income and wealth are formed in the future. Globalisation does not automatically lead all countries and economies to enrichment and better welfare. The consequences of globalisation may surprise us in a negative way. It is quite possible that the global financial crisis will continue for too long if we do not pay enough attention to automation and robotisation. These processes can be seen as a 'slow revolution' which brings about structural changes in the long run.

Modern research shows that technological development is not only progress in small steps. It is moving forward at an accelerated pace in many areas and can really surprise us in a radical way. Our laws, our culture, our attitudes and our social mechanisms have not evolved to meet the changes of technology waves. Maybe we are not ready for ubiquitous revolution and fast robotisation. However, this does not mean that changes will not take place.

6.6 Pessimistic scenario: Ford's automation hypothesis II

How does wealth creation logic change if ambient intelligence and robots took care of autonomous industrial production processes and perhaps also to a large extent social services? What may be the result for workers and for the economy in general? One answer is Ford's (2009) II hypothesis:

"At some point in the future – perhaps after many years or after decades later – machines can perform a large part of the average workers' works and the consequence is that these average workers will never find a new job."

It is clear that many experts do not agree with this hypothesis. They like to believe that in the economy we can at all times and under all circumstances create new jobs. The extent to which Ford's hypothesis II can become a reality is a challenge for modern economics. Scholar Ford (2009) has presented hypothetical calculations that the potential job loss could be 50%–60% of the working population. In practice, these are the people who drive cars, repair machinery and equipment, work as sellers in shopping malls, do office work, and are common in industrial units and plants, whose work can be given to robots and machines. They are so-called average workers.

The work is punctuated by the everyday life of many people, and it provides the essence of success and rich experience. Loss of employment can mean great human suffering. If 50% to 60% of people cannot find work, it is, of course, also a big drop in consumer demand in the market. Many mass markets lose their demand and this process can possibly drive societies to deeper recessions. The changes associated to Ford's (2009) hypothesis II also mean that people can no longer afford expensive products and services. Worst of all, the change can mean a serious threat to the capitalist market economy. Final consequence can be disequilibrium of supply and demand as production is increasing, but demand decreasing. Indeed, the consumer demand could decrease dramatically, leading to structural economic problems in many societies.

Only a small part of the world's population is very prosperous, and the purchasing power of global market is limited. Typically prosperity has been achieved in business or by saving. In developing countries people are saving, but in post-industrial countries people still focus on consumption. The global economy can only grow when the global middle class is growing. If robotisation and automation drive employment down, the

mass consumer market will lose most of demand. This can, in the worst case, derail the global economy into a long-term depression never experienced before (see Figure 14).

Such a future image represents large-scale problems in society. In particular, social problems will grow and civil peace is threatened. We have already seen pretty strong signals of this type of development in Europe, where many countries have a large segment of young people at the margins of the labour market. Is this a reasonable situation and outcome we like to have in the future?

The above-described worst-case scenario of Ford (2009, 2015) does not seem reasonable. Yet, we have too much wishful thinking; we are projecting reductionist visions and build our planning on hope and good wishes. If we understand current problems and challenges, this fact creates a positive pressure to move towards a better path of the future. This kind of future includes elements of genuine communal encounter, human accountability, peer support, and a strong civil society.

7 Pathfinder examples, programmes, and projects of European robotics

In a globally competitive environment, Europe and EU member countries are not only competing against low-wage developing economies, but also against highly automated economies. As the decade progresses robotics usage will increase around the world. In the competitiveness, productivity and sustainability battle, leadership in robotics technology will be a key strategic differentiator. In the US Robotics Strategy 'A roadmap for US robotics. From internet to robotics' this is a key starting point for strategic analyses (see Robotics-VO, 2013, SPARC, 2014a, 2014b).

In the current situation, Europe starts from a strong position in robotics, having 32% of current world markets. Industrial robotics has around one third (1/3) of the world market, while in the smaller professional service robot market European manufacturers produce 63% of non-military robots. The European position in the domestic and service robot market represents a market share of 14% and, due to its current size, this is also a much smaller area of economic activity in Europe than the other two.

Thus, service robotics is a strategic question for EU member countries. There are needs to anticipate disruptive technology roadmaps, because service robotics will show far more disruptive effects on the competitiveness of non-manufacturing industries such as agriculture, transport, healthcare, security and utilities. The growth of robotics in these clusters over the coming decade will be much more dramatic. From what is currently a relatively low base, service robots used in non-manufacturing areas are expected to become the largest area of global robot sales. The role of service robotics will be stronger than ever before.

One key activity in the field of robotics is the European Robotics strategy which has the title 'euRobotics AISBL – promoting excellence in European robotics' (<http://www.eurobotics-project.eu/>). This project aims to develop the field of robotics within the European Union. This activity is closely connected to SPARC – the partnership for robotics in Europe (SPARC 2014a, 2014b; <http://www.sparc-robotics.net/>). Figure 16 visualises estimates on the world robotics market developments and reachable European market shares.

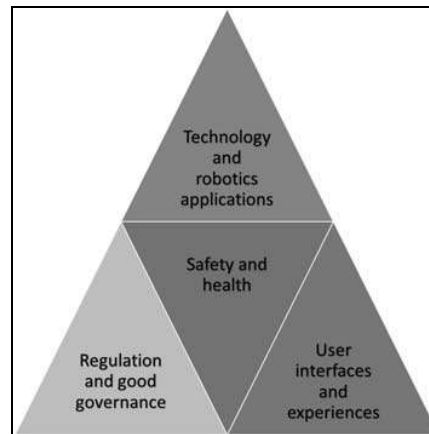
Figure 16 Safety and health triangle

Figure 15 illustrates that the effects of SPARC are noticeable in a significant uplift of the European market share (plus 14%) and a resulting additional turnover of approximately €44bn (cumulated over years 2014–2020). Growth rates and market shares of robotics are cumulated for the entire robotics domain from industrial, professional (without defence-related applications) and domestic service robotics. This figure motivates stakeholders to invest in the fields of robotics, especially in manufacturing and service robotics. The Horizon 2020 program also includes many elements relevant for robotics. Association Internationale Sans But Lucratif's (AISBL) and SPARC's main missions are:

- 1 to collaborate with the European Commission (EC) to develop
- 2 implement a strategy
- 3 a roadmap for research, technological development and innovation in robotics, in view of the launch of the next framework program Horizon 2020 (EU Robotics AISBL, 2014).

Towards this end, euRobotics AISBL was formed to engage from the private side in a contractual public-private partnership with the European Union as the public side. It is important to note that *euRobotics AISBL* is a Brussels-based international non-profit association for all stakeholders in European robotics (SPARC, 2014a, 2014b).

8 Summary

New technologies promise us many upsides like enhanced health, convenience, productivity and safety as well as more useful data, information and knowledge for people and organisations. The potential downsides are challenges to personal privacy, over-hyped expectations and increasing technological complexity that boggles us.

As presented in this article, robotics and AI with ongoing ubiquitous r/evolution will have impacts on safety and health issues. Robotics is not problem-free from this angle of human welfare. In this article a list of key challenges of robotics and AI were presented.

An underlined issue was the demand for European cooperation in meeting these big challenges.

The challenges of robotics and AI revolution require scientific discussion from the viewpoint of management, leadership and organisations – that means it is time to discuss the meaning of these challenges seriously also in terms of existing traditions of management and safety sciences, bearing in mind their importance already today. Digitalisation, robotics, AI, IoT and big data are most definitely key factors affecting societal development in the future.

Private and public organisations have begun to gain critical insights from big data, robotics and ubiquitous technology through various management systems. Basically, the issue at stake here is that it is not just a question of how to manage and control the technological possibilities. The development also concerns leadership functions. A robotised and automated society needs new kinds of management and leadership styles and organisational culture(s). Education and training need to be developed to meet these great challenges.

Taking the IoT, robotics and ubiquitous technology seriously may lead towards a revolution of digitalisation which affects management processes in organisations. The deployment of ongoing key processes call for strong leadership in the field of safety and health. Both the utilisation and the development of technologies as well as eliminating negative side effects of new robot applications are the key challenges in the ongoing technological transition period.

If the consequences of robotics and AI are taken seriously and professionally, special attention must be paid to:

- 1 technology management
- 2 user interfaces and experiences
- 3 regulation and good governance.

These three critical themes will require many European joint actions and development of good governance (see safety and health triangle in Figure 16).

When we adopt new technologies, the elements of safety and health triangle need more attention. There will be new technologies and applications of robotics and AI. New technologies provide new benefits, new costs, new possibilities and novel threats as history has shown. The widely held notion is that change is speeding up and the future will appear weirder, moving at a faster pace and evolving in a broader scope (Roth and Kaivo-oja, 2015) than we are used to track. It hence seems harder to keep up with new developments, especially in the field of robotics and AI where new inventions and innovations are introduced almost on a weekly basis.

A key question is to what extent can European citizens trust themselves in managing big technological transformations and how much support can they expect from public institutions and governments. If governments took a minimal role in managing big technology transformations, the approach leads to a minimal state policy. If we adopt the other approach, public-private partnership, as European Union has done in the European robotics strategy, citizens can expect more from governments and other agencies.

References

- Antoniou, G. and van Harmelen, F. (2004) *A Semantic Web Primer*, 2nd ed., The MIT Press, Boston.
- Ashton, K. (2009) *That 'Internet of Things' Thing* [online] <http://www.rfidjournal.com/article/view/4986> (accessed 13–29 March 2015).
- Atzori, L., Iera, A. and Morabito, G. (2010) 'The internet of things: a survey', *Computer Networks*, Vol. 54, No. 15, pp.2787–2805.
- Bell, D. (1974) *The Coming of Post-Industrial Society*, Harper Colophon Books, New York.
- Berners-Lee, T., Hendler, J. and Lassila, O. (2001) *The Semantic Web*, 17 May 2001, Scientific American, New York.
- Boisot, M.H. (1995) *Information Space: A Framework for Learning in Organizations, Institutions and Culture*, Routledge, London.
- Boisot, M.X. (1998) *Knowledge Assets. Securing Competitive Advantage in the Information Economy*, Oxford University Press, Oxford.
- Bostrom, N. (2014) *Superintelligence. Paths, Dangers, Strategies*, Oxford University Press, Oxford.
- Bowonder, B. and Miyake, T. (1994) 'Creating and sustaining competitiveness: an analysis of the Japanese robotics industry', *International Journal of Technology Management*, Vol. 9, Nos. 5–7, pp.575–611.
- Bowonder, B. and Miyake, T. (2000) 'Technology strategy of Toshiba corporation: a knowledge evolution perspective', *International Journal of Technology Management*, Vol. 19, Nos. 7–8, pp.864–895.
- Brynjolfsson, E. and McAfee, A. (2014) *The Second Machine Age. Work, Progress, and Prosperity in a Time of Brilliant Technologies*, W.W. Norton & Company, New York and London.
- Castells, M. (1996) *Rise of the Network Society*, Blackwell Publishers, Cambridge.
- Charles, K.K., Hurst, E. and Notowidigdo, M.J. (2013) *Manufacturing Decline, Housing Booms, and Non-Employment*, Tech. Rep., NBER Working Paper No. 18949, National Bureau of Economic Research, Cambridge, MA.
- Chen, P.T. and Hu, H.H.S. (2013) 'The mediating role of relational benefit between service quality and customer loyalty in airline industry', *Total Quality Management & Business Excellence*, Vol. 24, Nos. 9–10, pp.1084–1095.
- Chibani, A., Amirat, Y., Mohammed, S., Matson, E., Hagita, N. and Barreto, M. (2013) 'Ubiquitous robotics: recent challenges and future trends', *Robotics and Autonomous Systems*, November, Vol. 61, No. 11, pp.1162–1172.
- Chorost, M. (2011) *World Wide Mind: The Coming Integration of Humanity, Machines, and the Internet*, Simon and Schuster, New York.
- EU Robotics AISBL (2014) *Robotics 2020 Multi-Annual Roadmap n for Robotics in Europe, Call 1 ICT23 – Horizon 2020*, Initial Release B 15/01/2014 [online] http://www.eu-robotics.net/cms/upload/PDF/Multi-Annual_Roadmap_2020_Call_1_Initial_Release.pdf (accessed 16 March 2016).
- European Robotics Research Network (EURON) (2004) *Key Area 1 on "Research Coordination" – KAI. Robotics. Roadmapdiagram, s. 60. Verkkosivu* [online] <http://www.org.id.tue.nl/IFIP-SG16/robotics-roadmap-2004.pdf> (accessed 16 March 2016).
- Ford, M. (2009) *The Lights in the Tunnel: Automation, Accelerating Technology and the Economy of the Future*, Acculant Publishing, USA.
- Ford, M. (2015) *Rise of the Robots: Technology and the Threat of a Jobless Future*, Basic Books, New York.
- Freeman, C. (2001) 'Long-term structural changes: a re-appraisal', in Petit, P. and Soete, L. (Eds.): *Technology and the Future of European Employment*, pp.23–45, Edward Elgar, Cheltenham.

- Freeman, C. and Louçã, F. (2001) *As Time Goes By. From the Industrial Revolutions to the Information Revolution*, Oxford University Press, Oxford.
- Freeman, C. and Soete, L. (1994) *Work for All or Mass Unemployment? Computerised Technical Change into the Twenty-First Century*, Printer, London.
- Frey, C.B. and Osborne, M. (2013) *The Future of Employment: How Susceptible are Jobs To Computerisation?*, Oxford Martin School, Oxford [online] http://www.oxfordmartin.ox.ac.uk/downloads/academic/The_Future_of_Employment.pdf (accessed 16 March 2016).
- Gehl, R. (2011) 'The archive and the processor: the internal logic of web 2.0', *New Media and Society*, Vol. 13, No. 8, pp.1228–1244.
- Gratton, L. (2010) *The Shift: The Future of Work is Already Here*, Collins, London.
- Green, E.G. (2010) *Anywhere. How Global Connectivity Is Revolutionizing the Way We Do Business*, McGraw-Hill, New York.
- Greenfield, A. (2006) *Everyware: The Dawning Age of Ubiquitous Computing*, New Riders, Berkeley, CA.
- Grieco, L.A., Rizzo, A., Colucci, S., Sicari, S., Piro, G., Di Paola, D. and Boggia, G. (2014) 'IoT-aided robotics applications: technological implications, target domains and open issues', *Computer Communications*, 1 December, Vol. 54, No. 1, pp.32–47.
- Hahnel, R. (2005) *Economic Justice and Democracy: From Competition to Cooperation*, Routledge, New York.
- Haidegger, T., Barreto, M., Gonçalves, P., Habib, M.K., Ragavan, S., Kumar, V., Li, H., Vaccarella, A., Perrone, R. and Prestes, E. (2013) 'Applied ontologies and standards for service robots', *Robotics and Autonomous Systems*, Vol. 61, No. 11, pp.1215–1223.
- Hansmann, U., Merk, L., Nicklous, M. and Stober, T. (2004) *Pervasive Computing*, 2nd ed., Springer, Berlin.
- Hunter, R. (2002) *World Without Secrets. Business, Crime, and Privacy in the Age of Ubiquitous Computing*, John Wiley & Sons, New York.
- Jaimovich, N. and Siu, H.E. (2012) *The Trend is the Cycle: Job Polarization and Jobless Recoveries*, Tech. Rep., NBER Working Paper No. 18334, National Bureau of Economic Research, Cambridge, MA.
- Kaivo-oja, J., Kuusi, O., Ahlqvist, T., Linturi, R. and Roth, S. (in press) 'New industrial platforms and radical technology foresight: the case of 3-D printing in Finland and Europe', *International Journal of Manufacturing Technology and Management*, forthcoming, Inderscience.
- Kiehne, A. (2012) *Web 4.0 – The Web has Grown up. Are we Ready?* [online] <http://blog.ts.fujitsu.com/face2fujitsu/?p=4161> (accessed 16 March 2016).
- King, N.J. and Raja, V.T. (2012) 'Protecting the privacy and security of sensitive customer data in the cloud', *Computer Law & Security Review*, Vol. 28, No. 3, pp.308–319.
- Kreisler, H. (2001) *Identity and Change in the Network Society. Conversation with Manuel Castells. UC Berkeley, Conversations with History*, Institute of International Studies [online] <http://globetrotter.berkeley.edu/people/Castells/castells-con4.html> (accessed 16 March 2016).
- Kurzweil, R. (1999) *The Age of Spiritual Machines: When Computers Exceed Human Intelligence*, Viking Adult, USA.
- Kurzweil, R. (2005) *The Singularity is Near: When Humans Transcend Biology*, Viking Adult, USA.
- Lee, J.H., Phaal, R. and Lee, S.-H. (2013) 'An integrated service-device-technology roadmap for smart city development', *Technological Forecasting and Social Change*, February, Vol. 80, No. 2, pp.286–306.
- Machlup, P. (1962) *The Production and Distribution of Knowledge in the United States*, Princeton University Press, Princeton, NJ.

- Malaska, P. (2003) 'Synchronic – diachronic system analysis', in Höglund, R., Jäntti, M., Rosenqvist, G. (Eds.) *Statistics, Econometrics and Society: Essays in Honour of Leif Nordberg*, Statistics Finland Research Report 238, Statistics Finland, Helsinki.
- Massie, T.H. (1993) *Design of a Three Degree of Freedom Force-Reflecting Haptic Interface*, SB Thesis, Department of Electrical Engineering and Computer Science, MIT, Cambridge, MA.
- McEwen, B.S. and Wingfield, J.C. (2003) 'The concept of allostasis in biology and biomedicine', *Hormones and Behavior*, Vol. 43, No. 1, pp.2–15.
- McKinsey Global Institute (2013) *Disruptive Technologies: Advances That Will Transform Life, Business, and the Global Economy*, May, McKinsey & Company, New York.
- McNeill, J.R. and McNeill, W. (2003) *Human Web. A Bird's Eye View of World History*, W.W. Norton & Company, New York.
- Nora, S. and Minc, A. (1981) *The Computerization of Society: A Report to the President of France*, originally published in French in 1978 as L'informatisation de la société: rapport à M. le Président de la République, MIT Press, Cambridge, MA.
- O'Reilly, T. (2009) *What Is Web 2.0: Design Patterns and Business Models for the Next Generation of Software* [online] <http://oreilly.com/web2/archive/what-is-web-20.html> (accessed 16 March 2016).
- O'Sullivan, D. and Igoe, T. (2004) *Physical Computing: Sensing and Controlling the Physical World with Computers*, Thomson Course Technology, Boston, MA.
- Parsons, P.A. (1997) *Extreme Environmental Change and Evolution*, Cambridge University Press, Cambridge.
- Parsons, P.A. (2005) 'Environments and evolution: interactions between stress, resource inadequacy and energetic efficiency', *Biological Reviews*, Vol. 80, No. 4, pp.589–610.
- Pine II, B.J. and Korn, K.C. (2011) *Infinite Possibility. Creating Customer Value on the Digital Frontier*, Barrett-Koehler Publishers, San Francisco.
- Pink, D. (2009) *The Surprising Truth About What Motivates Us*, Riverhead, New York.
- Pistoni, F. (2014) *Robots Will Steal Your Job But That's OK*, ©Federico Pistoni, Seattle.
- Porat, M. (1977) *The Information Economy*, US Department of Commerce, Washington, DC.
- Robinson, M., Jones, K. and Janicke, K.H. (2015) 'Cyber warfare: issues and challenges', *Computers & Security*, March, Vol. 49, pp.70–94.
- Robotics-VO (2013) *A Roadmap for US Robotics. From Internet to Robotics. 2013 Edition. Robotics in the United States of America*, USA. [online] <https://robotics-vo.us/sites/default/files/2013%20Robotics%20Roadmap-rs.pdf> (accessed 16 March 2016).
- Ronzani, D. (2007) 'The battle of concepts: ubiquitous computing, pervasive computing and ambient intelligence in mass media', *Ubiquitous Computing and Communications Journal*, Vol. 4, No. 2, pp.9–19.
- Roth, S. (in press) 'Growth and function. A viral research program for next organizations', *International Journal of Technology Management*, forthcoming, Inderscience.
- Roth, S. and Kaivo-oja, J. (2015) 'Is the future a political economy? Functional analysis of three leading foresight and futures studies journals', *Futures*, online first, 22 October 2015 [online] doi:10.1016/j.futures.2015.10.002 (accessed 16 March 2016).
- Roth, S., Kaivo-Oja, J. and Hirschmann, T. (2013) 'Smart regions: two cases of crowdsourcing for regional development', *Review of International Journal of Entrepreneurship and Small Business*, Vol. 20, No. 3, pp.272–285.
- Sato, T., Nishida, Y. and Mizoguchi, H. (1996) 'Robotic room: symbiosis with human through behavior media', *Robotics and Autonomous Systems*, Vol. 18, Nos. 1–2, pp.185–194.
- Schumpeter, J.A. (2013) *Capitalism, Socialism and Democracy*, Routledge, London.
- Sicari, S. Rizzardi, A. Grieco, L.A. and Coen-Porisini, A. (2015) 'Security, privacy and trust in internet of things: the road ahead', *Computer Networks*, Vol. 76, pp.146–164.

- SPARC (2014a) *Robotics in Europe. Introduction* [online] <http://www.sparc-robotics.net/robotics-in-europe/> (accessed 16 March 2016).
- SPARC (2014b) *Strategic Research Agenda for Robotics in Europe 2014-2020*. ©euRobo (cs aisbl 2013 & 2014) [online] http://www.eu-robotics.net/cms/upload/PPP/SRA2020_SPARC.pdf (accessed 16 March 2016).
- Stappers, P.J. (2006) 'Creative connections: user, designer, context, and tools', *Personal and Ubiquitous Computing*, Vol. 10, Nos. 2–3, pp.95–100.
- Stehr, N. (2002) *Knowledge & Economic Conduct*, University of Toronto Press, Toronto.
- Strambach, S. (2008) 'Knowledge-intensive business services (KIBS) as drivers of multilevel knowledge dynamics', *International Journal Services Technology and Management*, Vol. 10, Nos. 2/3/4, pp.152–174.
- TechCast (2014) *Technology Forecasts*, December [online] <https://www.techcastglobal.com/documents/10193/0/Tech+Forecasts/0a4363df-2287-4da1-821e-05d9ec984c42> (accessed 16 March 2016).
- Toffler, A. (1970) *Future Shock*, Random House, New York.
- Toivonen, M. (2004) *Expertise as Business. Long-term Development and Future Prospects of Knowledge-intensive Business Services*, Dissertation, Helsinki University of Technology, Department of Industrial Engineering and Management, Helsinki.
- Touraine, A. (1971) *The Post-Industrial Society. Tomorrow's Social History: Classes, Conflicts and Culture in the Programmed Society*, Random House, New York.
- UNESCO (2005) *Towards Knowledge Societies*, UNESCO World Report, UNESCO Publishing, Paris [online] <http://unesdoc.unesco.org/images/0014/001418/141843e.pdf> (accessed 16 March 2016).
- van Dijk, J. (2006) *The Network Society*, 2nd ed., Sage, London.
- Viherä, M.L. (2010) 'Työn yksilöllinen ja yhteisöllinen merkitys ihmiselle', *Futura*, Vol. 29, No. 1, pp.1–6.
- Viherä, M.-L. (1999) *Ihminen tietoyhteiskunnassa. Kansalaisten viestintävalmiudet kansalaisyhteiskunnan mahdollistajana [People and Information Society. The Citizens' Communication Skills and the Opening of New Prospects for the Civil Society]*, Turun kauppakorkeakoulun julkaisuja Sarja A-1: 1999, Turun kauppakorkeakoulu, Turku.
- Weber, W., Rabaey, J.M. and Aarts, E. (Eds.) (2005) *Ambient Intelligence*, Springer, Berlin.
- Weiser, M. (1991) 'The computer for the 21st century', *Scientific American*, Vol. 265, No. 3, pp.94–104.
- Wilbert, B. (1997) 'Cultural meanings in transition: a crisis at work', in P. James, W.F. and Wright, S. (Ed.): *Work of the Future. Global Perspectives*, pp.79–87, Allen & Unwin, Australia.

Selected Publications of Jari Kaivo-oja and Steffen Roth

Journal articles

1. Luukkanen, Jyrki, Panula-Ontto, Juha, Vehmas, Jarmo, Liyong, Liu, Kaivo-oja, Jari, Häyhä, Laura & Auffermann, Burkhard (2015) Structural Change in Chinese Economy: Impacts on Energy Use and CO2 Emissions in the Period 2013–2030. *Technological Forecasting and Social Change*. Vol. 94, May 2015, pp. 303–317.
2. Virtanen, Petri & Kaivo-oja, Jari (2015) Public service systems and emerging systemic governance challenges. *International Journal of Public Leadership*. Vol. 11 Iss: 2. ISSN: 2056-4929.
3. Auffermann, Burkhard, Suomela, Pertti, Kaivo-oja, Jari, Vehmas, Jarmo, Jyrki Luukkanen, Jyrki (2014) Final solution for the nuclear waste challenge in Finland? Recent policies on the disposal of nuclear waste. Forthcoming in “Governance of Nuclear Waste Management”. International book edition. © Springer, 19 p.
4. Kaivo-oja, Jari, Panula-Ontto, Juha, Luukkanen, Jyrki, Vehmas, Jarmo, Chen, Y., Mikkonen, S. & Aufferman, Burkhard (2014) Are Structural Change and Modernisation Leading to Convergence in the CO2 Economy? Decomposition Analysis of China, EU and USA. *Energy, the International Journal*. Vol. 72, August 2014, pp. 115-125.
5. Kaivo-oja, Jari (2014) Three Theoretical Approaches to Pirate Entrepreneurship: Towards Futures and Problem-oriented Research of Pirate Entrepreneurship. *International Journal of Entrepreneurship and Small Business*. Special Issue “Pirate Entrepreneurship”. Vol. 22, No. 4, pp. 449-465. ©Inderscience Publishers
6. Olsmats, Carl & Kaivo-oja, Jari (2014) European Packaging Industry Foresight Study - Identifying Global Drivers and Driven Packaging Industry Implications of the Global Megatrends. *European Journal of Futures Research*. Vol. 2., No. 1, 1-10. Springer.
7. Santonen, Teemu, Kaivo-oja, Jari & Suomala, Jyrki (2014) The Next Steps in Developing the Triple Helix Model: A Brief Introduction to National Open Innovation System (NOIS) Paradigm Forthcoming in the *Journal of Systemics, Cybernetics, and Informatics (JSCI)*, Vol. 12. In print.
8. Kaivo-oja, Jari & Karppinen, Ari (2014) Lukukausimaksut ja yliopistojen houkuttelevuus - Mitä tilastot ja kansainväliset tutkimukset kertovat? Vai kertovatko mitään suomalaisesta perspektiivistä? *Katsaus. Tiedepolitiikka*, Vol. 39., No. 1/2014, pp. 45-56.
9. Kaivo-oja, Jari (2014) Development Aid Beyond 2015? Aid Effectiveness Evaluated by World Bank Indicators and Millennium Development Goals (MDGS) – A Trend Benchmarking Study in Kenya, Tanzania and Sub-Saharan Africa. Finland Futures Research Centre. Turku School of Economics. FFRC eBooks 6/2014. ISBN 978-952-249-279-1. University of Turku. Turku. 58. p.
10. Pasanen, Tytti, Tuominen, Visa, Keskiäli, Ilkka, Lakkala, Hanna, Akgün, Orkide, Luukkanen, Jyrki, Kaivo-oja, Jari & Panula-Ontto, Juha (2013) Energy, Environment and Livelihoods in the Lao PDR. Results from a 2011 Household

- Survey. Finland Futures Research Centre. Turku School of Economics. FFRC eBook 5/2013. Turku. 164 p. ISBN 978-952-249-261-6, ISSN 1797-1322.
11. Kaivo-oja, Jari (2013) New Service Design Thinking in the Ubiquitous Media. *Touchpoint*, Vol. 5, No. 3, pp. 34-40.
 12. Kaivo-oja, J. (2013) Scenario Analyses of the Futures of Journalism Profession. *Journal of Futures Studies. Epistemology, Methods, Applied and Alternative Futures*, Vol. 18, No. 2, pp. 60-84. ©Graduate Institute of Futures Studies. Tamkang University, Tamsui Campus.
 13. Kaivo-oja, Jari, Santonen Teemu, Myllylä, Yrjö (2013) The Crowdsourcing Delphi: Combining the Delphi Methodology and Crowdsourcing Techniques. This paper will be presented at The XXIV ISPIM Conference – Innovating in Global Markets: Challenges for Sustainable Growth in Helsinki, Finland on 16-19 June 2013. Session: 2.2 Strategic Foresight, Strategic Agility and Future Orientation (SIG) Special Session. The publication is available to ISPIM members at www.ispim.org.
 14. Haukioja, Teemu, Karppinen, Ari & Kaivo-oja, Jari (2013) Maksuton yliopistokoulutus – riippakivi vai menestystekijä? Tiedosta kauppatavaraa? [Free university education: burden or success factor?]. Teoksessa Johana Harju ja Juuso Leivonen (Toim.) Näkökulmia koulutuksen kaupallistumiseen ja kansainvälistymiseen. [Perspectives on the Commercialization of Education and Internationalization]. SYL-julkaisu 2/2013. Suomen ylioppilaskuntien liitto ry. Helsinki: Trinket Oy, pp. 22-35.
 15. Kaivo-oja, Jari & Karppinen, Ari (2013) Lukukausimaksut ja yliopistojen houkuttelevuus. Mitä tilastot ja kansainväliset tutkimukset kertovat? [Tuition fees and the attractiveness of universities. What statistical and international studies tell to us?] *Tiedepolitiikka*. Vol. 38, No. 1, 52-65.
 16. Haukioja, Teemu, Karppinen, Ari & Kaivo-oja, Jari (2013) Paljonko on motivaatiosi? Yliopistojen sisäänoton monikriteerinen arviointikehikko. [How motivated you are? Multicriteria evaluation framework to recruit students to universities] *Tiedepolitiikka*. Vol. 37, No. 3, pp. 17-30.
 17. Kaivo-oja, J., Panula-Ontto, J., Luukkanen, J. & Vehmas, J. (2013) Relationships of the Dimensions of Sustainability as Measured by the Sustainable Society Index Framework. *International Journal of Sustainable Development and World Ecology*. Vol. 21, No. 1, pp. 39-45.
 18. Kaivo-oja, Jari & Stenvall, Jari (2013) Foresight, Governance and Complexity of Systems: On the Way towards Pragmatic Governance Paradigm. *European Integration Studies*. No. 7, pp. 28-34.
 19. Roth, S. and Kaivo-oja, J. (in press), Is the future a political economy? Functional analysis of three leading foresight and futures studies journals, *Futures*, online first October 22, 2015.
 20. Roth, S. (in press), Growth and function. A viral research program for next organisations, *International Journal of Technology Management*, forthcoming.
 21. Roth, S. and Dana, L. (in press), What's your self-made expat story? Netnography of entrepreneurial re-users of a popular semantic, *International Journal of Entrepreneurship and Small Business*, forthcoming.
 22. Roth, S. (2015), Free economy! On 3628800 alternatives of and to capitalism, *Journal of Interdisciplinary Economics*, Vol 27 No. 2, 107-128.

23. Roth, S. (2015), Serious gamification. On the redesign of a popular paradox, Games and Culture, online first April 2015.
24. Roth, S., Schneckenberg, D. and Tsai, C.-W. (2015), The ludic drive as innovation driver: Introduction to the gamification of innovation, Creativity and Innovation Management, Vol. 24 No. 2, pp. 300-306.
25. Roth, S. (2014), The multifunctional organization: Two cases for a critical update for research programs in management and organization, Tamara: Journal for Critical Organization Inquiry, Vol. 12 No. 3, pp. 37-54.
26. Roth, S. (2014), Fashionable functions. A Google ngram view of trends in functional differentiation (1800-2000), International Journal of Technology and Human Interaction, Vol. 10 No. 2, 34-58.
27. Roth, S. (2014), Booties, bounties, business models. A map to the next red oceans, International Journal of Entrepreneurship and Small Business, Vol. 22 No. 4, 439-448.
28. Roth, S. (2014), The eye-patch of the beholder. Introduction to entrepreneurship and piracy, International Journal of Entrepreneurship and Small Business, Vol. 22 No. 4, 399-407.
29. Roth, S. (2014), The things that go without saying. On performative differences between business value communication and communication on business values, International Journal of Business Performance Management, Vol. 15 No. 3, 175-191.
30. Roth, S. (2014), Coining societies. An inter-functional comparative analysis of the Euro, Innovation: The European Journal of Social Sciences, Vol. 27 No. 4, 99-118.
31. Roth, S. (2013), Common values? Fifty-two cases of value semantics copying on corporate websites, Human Systems Management, Vol. 32 No. 4, pp. 249-265.
32. Roth, S., Kaivo-oja, J. and Hirschmann, T. (2013), Smart regions. Two cases of crowdsourcing for regional development, International Journal of Entrepreneurship and Small Business, Vol. 20 No. 3, pp. 272-285.
33. Roth, S. (2013), Dying is only human. The case death makes for the immortality of the person, Tamara: Journal for Critical Organization Inquiry, Vol. 11 No. 2, pp. 37-41.
34. Roth, S. (2012), Leaving commonplaces on the commonplace. Cornerstones of a polyphonic market theory, Tamara: Journal for Critical Organization Inquiry, Vol. 10 No. 3, pp. 43-52.
35. Roth, S. (2012), The moral of functional differentiation. A new horizon for descriptive innovation ethics, Electronic Journal of Business Ethics and Organization Studies, Vol. 17 No. 2, pp. 27-34.
36. Jaccard, D. and Roth, S. (2012), Formation à la gestion de projet et simulations, Revue Economique et Sociale, Vol. 70 No. 2, pp. 79-88.
37. Roth, S. (2011), Les deux angleterres et le continent. Anglophone sociology as the guardian of Old European semantics, Journal of Sociocybernetics, Vol. 9 No. 1-2, pp. 19-34.
38. Roth, S. (2011), Erinnerungsdesign in Armenien. Ein Staat an seinen Grenzen, Revue für Postheroisches Management, Heft 8 (Design Thinking), pp. 106-111.

39. Roth, S. (2010), The Diaspora as a nation's capital: Crowdsourcing strategies for the Caucasus, *International Journal of Transition and Innovation Systems*, Vol. 1 No. 1, pp. 44-58.
40. Roth, S. (2009), New for whom? Initial images from the social dimension of innovation, *International Journal of Innovation and Sustainable Development*, Vol. 4 No. 4, pp. 231-252 [VHB].
41. Roth, S., and Aderhold, J. (2008), World society on the couch: anti-terror consultancy as an object and test-bed of professional sociology, *HUMSEC Journal*, Vol. 2, No. 1, pp. 67-83.
42. Roth, S., Mkrtchyan, A. and Vartikyan, A. (2011), Armenia, in Barnett, G. and Golson, J. G. (eds), *Encyclopedia of social networks*, Thousand Oaks, SAGE Publishing, pp. 56-57.
43. Roth, S. (2010), Zu den Grenzen des Gemeinplatzes vom wirtschaftlichen Markt: Ecksteine einer allgemeinen Marktsoziologie, in Pahl, H. und Meyer, L. (Hrsg), *Gesellschaftstheorie der Geldwirtschaft*, Marburg, Metropolis.
44. Roth, S. (2009), Introduction. Towards a theory of robust innovation. In Roth, S. (ed.) *Non-technological and Non-Economic Innovations: Contributions to a Theory of Robust Innovation*, Bern, Peter Lang.
45. Рот, С. (2009), Каковы перспективы краудсорсинга? Транснациональные стратегии открытых инноваций для предотвращения "утечки умов" из стран СНГ Перевод с английского, Пипия, Л. К. (сост.), *Общественные и гуманитарные науки: тенденции развития и перспективы сотрудничества*, М., Ин-т проблем развития науки РАН.