EUROPEAN JOURNAL OF WORKPLACE INNOVATION

Why Industry 4.0 needs Workplace Innovation: a critical look at the German debate on advanced manufacturing

Ralf Kopp, Jürgen Howaldt and Jürgen Schultze

Abstract

Behind labels in the international debate such as "autonomics" and "advanced manufacturing" hides the attempt to accelerate the digitalisation of production. In Germany, the future of manufacturing is intimately bound up with the vision of Industry 4.0. Despite considerable uncertainties and risks, and despite negative experiences with such technology-centred approaches in the past (e.g. with concepts such as the "fully automated factory" or "Enterprise 2.0"), there is a broad, almost unbroken consensus between social partners and policy-makers. Widespread implementation of this technology-centred vision appears to be necessary and crucial for competitiveness, and without alternatives, so that only the question of its socially acceptable design remains to be answered. Our article aims to show, however, that there are alternatives to a concept based on a one-sided, technology-oriented understanding of innovation. It therefore makes an important difference whether Industry 4.0 or Workplace Innovation stands at the centre of such far-reaching plans for the future.

Keywords: Autonomics, advanced manufacturing, smart factory, social innovation, Workplace Innovation, socio-digital system design

Introduction

In the international debate, the digitalisation of industry and development of "advanced manufacturing" occupy an important position as significant factors for maintaining competitiveness and safeguarding jobs. In Germany, in recent years, the term "Industry 4.0" has increasingly featured in this debate. Given that the capabilities of digital systems are unquestionably increasing, there appears to be compelling evidence for the Industry 4.0 model and, despite its essential technological determinist features, it is hardly ever questioned in design-oriented discourse. We argue that the debate surrounding Industry 4.0 is in need of considerable relativisation, or rather reorientation, in light of a new innovation paradigm, so that the real challenges in the transition to a knowledge-based society are not missed. Effective approaches should build on existing strengths. One suitable approach which could excellently integrate the various participative working cultures specific to Europe and the new requirements of Industry 4.0, is a consistent orientation to high involvement innovation practices. Similar approaches have been developed in many European countries, with names such as "high performance workplaces", "high involvement workplaces", "innovative workplaces", "sustainable work systems" and "employee driven innovation" (cf. Pot 2012, p. 262). In essence, these concepts are about emphasising the close relationship between "organisational performance (labour productivity, innovation capabilities)" and "better jobs (competence development, wellbeing at work)" (cf. Pot & Dhondt forthcoming). Furthermore, a sustainable approach should take into account the contribution to be made by future industrial structures to addressing the big social challenges. After briefly outlining the concept and its significance in the international discussion, we define the contours of a new innovation paradigm, which focuses on the question of the conditions for developing and maintaining modern societies' capacity for innovation. We then we use two examples ("Halle 54" and "Enterprise 2.0") to illustrate the dysfunctionalities and contradictions of a technology-centred approach, whose excessive automation ambitions, despite having failed repeatedly, are currently experiencing a resurgence in Industry 4.0. In contrast, the development of sustainable and integrated business models, and the enhancement of companies' ability to innovate through comprehensive utilisation of the potential of their employees and of society, tend to receive little exposure in the questionable debate.

Vision, core objective and promoters of Industry 4.0 in Germany

Accents have shifted considerably in recent years in the current debate on the future of the German economy. While terms such as "lean production", "knowledge-based economy", "knowledge work" and "Enterprise 2.0" until a short time ago influenced many views of the future, they have increasingly fallen into the background in recent years with the spread of the Industry 4.0 concept (cf. Bauer et al. 2014, p. 12). According to a current definition, Industry 4.0 is a term which refers to "the fourth industrial revolution, a new level of organisation and management of the entire value chain across the product life-cycle. This cycle is geared to increasingly individualised customer wishes, and extends from the idea, the development and production work, and the delivery of a product to the end customer, to recycling, including the associated services. It is based on the availability of all relevant information in real-time as a result of networking all the parties involved in value creation, and on the ability to infer from the data the optimal value stream at any time. Linking people, objects and systems creates dynamic, real-time optimised, self-organising and inter-enterprise value creation networks which can be optimised according to various criteria such as costs, availability and resource usage" (Plattform Industrie 4.0 2015, p. 3)

The term Industry 4.0 was introduced in 2011 at the Hanover Fair in Germany and covers the most important activities and projects from the German government to promote computerisation of the manufacturing industry (smart factory). In 2012 it became the focus of a working group on Industry 4.0 chaired by Robert Bosch GmbH and acatech. Their implementation recommendations to the German federal government were presented in April 2013 again at the Hanover Fair in a final report. The three industry associations Bitkom, VDMA and ZVEI followed on from this to create an "Industry 4.0 platform", "to put the pre-competitive conditions in place for the economic implementation and realisation of the Industry 4.0 vision […]. Through dialogue involving different sectors, the aim is to develop concepts for technologies, standards, business models and organisation models, and promote their practical implementation" (ibid.) According to its protagonists, the "Internet of Things" is increasingly penetrating all social aspects of production, services, trade and consumption. The authors of one of the key studies on the topic write that Industry 4.0 centres on "the real-time capable, intelligent, horizontal and vertical networking of humans, machines, objects and ICT systems for the dynamic management of complex systems" (Bauer et al. 2014, p. 18). Custom products should be manufacturable at bulk-product prices, as a result of humans, machines and artefacts communicating with each other, and the emergent product is so computerised that it can optimise its own production process. Industry 4.0 holds out the prospect of a completely new logic and quality of production management, which should make it possible for "intelligent products, machines and equipment to exchange information autonomously, initiate actions and control each other independently in real-time" (ibid.) Networking does not end at the factory gate, rather it encompasses the relationship between factories and suppliers, with the result that it can extend to form widespread value creation networks. The concept is being driven "by computer scientists, engineers, innovation policy actors, influential business associations and larger technology-intensive enterprises" (Hirsch-Kreinsen 2014, p. 421). The Industry 4.0 working group represents the core of the promoters (cf. Kagermann et al. 2013). The question of designing the future of work assumes a central position in this discussion, and is influenced by social partners (cf. Botthof & Hartmann 2015; IGM NRW 2013) as well as by social science and work science (cf. Hirsch-Kreinsen 2014). Impacts at the level of production systems and on the various enterprise hierarchy levels and functions are currently debated in terms of opportunity and risk, depending on the specific design. These debates are also concerned with quality of work, and with "concepts for job structures that are geared to acceptance, potential for achievement and development, well-being and the health of working people. This is about questions such as how well working environments in *Industry 4.0* promote learning, the interaction between machines/robots and humans, as well as new opportunities linked to employment policy solutions" (Botthof & Hartmann 2015, p. VI).

Similar discussions and strategies can be observed internationally. In the United States, similar development activities are being promoted by the Smart Manufacturing Leadership Coalition (SMLC) (cf. SMLC 2011). "SMLC will lead the industrial sector transformation into a networked, information-driven environment in which an open Smart Manufacturing Platform supports real-time, high value applications for manufacturers to optimise production systems and value chains, and radically improve sustainability, productivity, innovation and customer-service. […] SMLC is developing a shared infrastructure (SM Platform) that will enable the implementation of Smart Manufacturing capabilities, to create a step change in manufacturing. The SM platform will promote next-generation economic, energy, sustainability and EH&S manufacturing performance and global competitiveness" (SMLC 2015). China is seeking to advance Industry 4.0 with a national strategic programme called "Made in China 2025", which was announced in March 2015. A recent comparative study

(looking at the United States, China and Europe) by the Fraunhofer Institute points out that China has edged slightly ahead with regard to the number and quality of relevant patents (cf. Fraunhofer IAO 2015).

The European approach centres on raising the competitiveness of industry and industrial production (advanced manufacturing), while securing innovative capacity, productivity, growth and employment. Related discussions about "high-tech manufacturing processes" and "key enabling technologies" are embedded in an overall concept which addresses both the changed demand for high-quality and sustainable products, and aspects such as resource efficiency and economic sustainability. From this perspective, advanced manufacturing does not mean technology-centred manufacturing, but rather human-centred manufacturing and designing the workplaces of the future. The projects funded so far under the "European Economic Recovery Plan" cover the entire spectrum of manufacturing/production (Factories of the Future, FoF at a Glance): supply chain configurations, virtual factories, material processing and handling, programming and planning, customer-driven design, energy efficiency, emissions reductions, new processing technologies, new materials, upgrading of existing machines and technologies. Horizon 2020: the EU Framework Programme for Research and Innovation 2014-2020 which pools European development programmes and activities, plays an important role. Special importance attaches to the new contractual Public-Private Partnership (PPP) programme, e.g. Factories for the Future (FoF) as well as SPIRE and the European Factories of the Future Research Association (EFFRA).

Below the European level, the situation is characterised by a large number of different national initiatives. Independent approaches, with their own label, can be identified in nearly every country. The German debate is conducted with "Industry 4.0" as the term of reference, often giving the impression that this is not just a desirable but ultimately an inevitable development, which fundamentally has no alternatives. Yet this fails to appreciate that, as Kärcher also points out, any "statement concerning Industry 4.0, its design and its consequences [...] at the present time [is] necessarily speculative." So far, there are only limited concrete experiences in industry" (Kärcher 2014, p. 19). Noticeable reserve in wide sectors of industry (cf. Becker 2014) is also often ignored. Sometimes the vehemence of the debate strongly suggests that it is a fad, such as Kieser (1996) diagnosed in the 1990s as ever new management concepts kept emerging.

A look at the European discussion shows that there are not only alternative ways of implementing Industry 4.0, but also that the development of alternative concepts to Industry 4.0 is possible and necessary. The hype surrounding Industry 4.0 appears to be a German phenomenon, and so far it has occurred primarily at the discursive level[i]. Even though the vision starts with existing information and communication technology (ICT) conditions and a small number of dedicated Industry 4.0 pilot projects, it has received only a modest reception at the practical level, especially among broad swathes of Germany's *Mittelstand.* This is not necessarily due to information deficits, a lack of innovative spirit or slowness to react. It could also be interpreted as prudence or as a greater affinity for alternative innovation and production approaches, which certainly exist aside from Industry 4.0. It is still completely open as to which forms and labels will become established in the medium and long term. "There is no 'natural law' by which the future reality can be determined in advance. The future will depend on many decisions that are taken in politics, science and especially in business" (Kärcher 2014, p. 22).

A new innovation paradigm

In terms of innovation strategy, Industry 4.0, trusting in the power of engineering, pursues the approach of a technological "push": a concept that is closely associated with a one-sided technology-focused understanding of innovation. Yet the potentials of the knowledge-based society and economy could be better unlocked through alternative strategies as part of a new innovation paradigm (cf. Bullinger 2006; FORA 2010; Howaldt & Schwarz 2010). Key categories here are the opening of the innovation process towards society, orientation to social challenges, social innovation and the capacity for innovation. Particularly the opening of the innovation process towards society (cf. FORA 2010, pp. 15 ff.) is a central feature of a changed innovation paradigm. Businesses, universities and research institutes are not the only relevant actors in the innovation process. Citizens and customers no longer serve only as suppliers of information about their needs (as is the case in classical innovation management), as instead they bring information about solutions into the development process for new products. Terms and concepts such as "open innovation" (Chesbrough 2003), customer integration (Jacobsen 2005), and networks (Howaldt et al. 2001) mirror important aspects of this development.

At the same time, social innovations come into focus, in the sense of the reconfiguration of social practices and their establishment in particular sectors of society (cf. Howaldt & Schwarz 2010). Examples range from civil society (environmental movement, new forms of living arrangements) to the area of state action (social insurance), and the economy (learning organisation, new management concepts, new services) (cf. Gillwald 2000, pp. 3 f.) A significant milestone in anchoring social innovations in German innovation policy is the German federal government's new high-tech strategy. The intention is clearly formulated: "We are focusing on a wider understanding of innovation, including not only technological but also social innovations, which involves society as a central actor. We are looking at the whole picture and we consider together that which belongs together" (BMBF 2014, p. 4). Thus attention is shifting from the market potential of individual technology fields to society's need for sustainable solutions and their realisation. "Now it is a matter of bringing these strands together and considering all key aspects of a comprehensive research and innovation policy in context. This creates an optimal environment for ideas, their implementation in marketable products and services, more value creation and potential for new future-proof jobs" (ibid. 11). Considerations focus on enhancing innovative capacity by stepping up dialogue with a wide variety of stakeholders across organisational boundaries (networking, open innovation): including a broad spectrum of social actors. However, the development of innovative capacity in this sense is a process that depends on many conditions and creates major challenges for the actors involved: in business, science, politics and society. While the debate surrounding national and regional innovation systems is predominantly concerned with the structural, political and institutional conditions for innovativeness at national and regional level, in the BMBF programme "Working – learning – developing skills – innovative capabilities in a modern working world", interest focuses in particular on management and work-related aspects of innovativeness. Terms such as organisation, qualification, technology and health are of central importance here. To enhance innovative capacity, attention at the enterprise level focuses on activities and the creation of conditions conducive to innovation by initiating and supporting learning processes, skills development, and participative forms of organisation (cf. Hartmann 2014).

Technological determinism 4.0

In light of the above, the debate concerning Industry 4.0 feels like being transported back to another era. Last century, in the 1950s and 1960s, there were widespread attempts to draw far-reaching conclusions from technological developments for the design of organisational structures and work. In their ground-breaking study for the subsequent debate on the relationship between technology and work, "Industrial labour and worker consciousness" (1970), Kern and Schumann note: "In the literature on the sociology of industry, there is a concept that proved to be particularly appealing, which embeds the historical relationship between industrial technology and human labour in a three-phase model" (Kern & Schumann 1970, p. 27). The model is guided by the assumption that the respective technological conditions lead to workers being employed in particular ways, and determine the skill sets that are needed. One "assumed a rising line of development from skilled crafts and trades to mechanisation (assembly line production) and then to automation; to this corresponded, respectively, the worker-types of the autonomous craftsman, the heteronomous low-skilled worker on the production line, and finally the requalified worker now doing hardly any physical work" (Pfeiffer 2010, pp. 234 f.) In the 1970s, the three-phase model was increasingly surpassed in industrial sociology, and the "end of technological determinism" (Lutz 1987) became the new basic consensus. This was combined with an understanding of innovation in which technological and social innovations are mutually dependent. Nevertheless, at first these insights were slow to have any practical effect. Both in the popular idea of technological development and in the social-science (sociological) discourse of innovation research, the primacy of technology, even if in an enlightened version, remained dominant. This technology-centred view led to spectacular failures in the past, yet seems to be gaining new impetus in the Industry4.0 debate. Thus we read today: "Industry 4.0 is feasible, human 4.0 not so easily" (MTM aktuell 2014, p. 4), or as the headline in Wirtschaftswoche magazine declares even more directly: "Let the machine take command" (Eisert 2014). The examples of "Halle 54" and Enterprise 2.0 illustrate the problematic consequences of taking this view, and show clear analogies with the current debate on Industry 4.0.

The notion of Industry 4.0 in general, and of the smart factory in particular, is remarkably reminiscent of the disappointed hopes in the 1980s of a fully automated factory in the automotive industry. "Halle 54" was a production and final assembly hall at Volkswagen's Wolfsburg plant, which at the time of its commissioning in 1983 was considered to be an advanced computer-integrated manufacturing (CIM) concept and blueprint for a fully automated factory. It was accompanied by promises of higher productivity and the elimination of monotonous activities in favour of the highly-skilled jobs that remained. Its failure became legendary. Instead, new concepts of production and organisation (e.g. "lean production", teamwork, learning organisation) found their way into the day-to-day activities of many businesses that were aiming to comprehensively exploit the potentials of human labour (cf. for example Kern & Schumann 1984; Minssen et al. 1991). Early on, in experiments with "Halle 54", and moreover not only due to strategic calculations with respect to acceptance, extreme variants of the notion of a fully automated factory without human workers were replaced by variants more akin to a factory without so many workers. Even at that time, the focus was meant to be on the (remaining) humans, and even then it seemed important to design the new processes and work tasks so that they enabled higher-skilled (through an increase in programming, controlling and analytical tasks) and more humane work (by eliminating monotonous activities). Back then, it was said that "Robby [the robot] does the dirty work" (Autogramm no. 2/1982, p. 5, quoted in Heßler 2014, p. 6) and would free humans from irksome activities to the benefit of new intellectual monitoring and control tasks

(cf. ibid.) Today they say "the robot is becoming a co-operating partner" (Wischmann 2014, p. 72). Towards the end of the 1980s, comprehensive full automation ambitions, not only at Volkswagen, began to be abandoned, particularly since complex final assembly could not be carried out to satisfaction in this way, and to this day the use of human labour is indispensable (cf. Heßler 2014, p. 15). Among the main problems were a lack of flexibility and an excessive error rate. There was a marked increase in production stoppages, downtime and rectification work. A large gap opened between desire and reality. In light of this, Hack described the concept of Halle 54 "as a dinosaur of a technologistic narrowing of rationalisation/modernisation, in which now even the organisations were interpreted 'as technology'" (Hack 1994, p. 53). Thus the model ultimately failed because of its radically contra-anthropocentric rationalisation strategy. "The idea of a fully automated factory ran up against its material limits just as Taylorism reached its limits as a model for the organisation of work and production" (Pfeiffer 2010, p. 233).

Since then, a "variety of more or less innovative production concepts have emerged" (Heßler 2014, p. 16), which focus on the social and cultural aspects of business organisation and management. According to Heßler, the 1990s are characterised by the coexistence and mixing of different concepts, in which the relationship between humans and machines is configured context-specifically. Nevertheless, robots continued to be developed, and work was indeed successfully done to "enable them to identify errors or deviations in the process themselves, and learn from this" (ibid.): in other words, so that they gather experience-based knowledge. These old discussions have striking similarities to the current debate, with the result that in the context of the design of work as well, there are reflections on whether "in precisely the context of Industry 4.0, the time has come to implement a few 'old' ideas" (Hartmann 2014, p. 7). The experiences of Halle 54 can teach us not only that the social aspects need to be incorporated into the vision and architecture of technology design from the outset, but also that there is a need for a realistic assessment of the reach of the concepts. It can be assumed, for instance, that such advanced technologies can be usefully applied only in particular industries and areas of production, and that alternative production and innovation concepts are always available. Even if *Industry 4.0* is "treated from the outset as a socio-technical system, in which humans are to remain central as comprehensive decision-makers or as cognitive all-rounders" (Howaldt & Kopp 2015, p. V6), the current debate is astonishingly close to the technology-centred logic of that time. A more recent example of the narrowness and riskiness of technology-driven concepts of production and organisation is the discussion about Enterprise 2.0. At the end of 2010, "Enterprise 2.0" (about which we now hear a good deal less) was being promoted by in some cases the same protagonists who today favour Industry 4.0 (e.g. Bitkom, CeBIT). Even the initial definition of Enterprise 2.0 could not conceal its technological orientation: "Enterprise 2.0 is the use of emergent social platforms within companies, or between companies and their partners or customers" (McAfee 2006, n.p.) With few exceptions (e.g. Koch & Richter 2009; Back & Heidecke 2009), the academic debate largely reflected assumptions from practice (especially those of software providers), which followed the simple equation: Enterprise 2.0 = use of Web 2.0 in enterprises. "In places where a difference is asserted, the term Enterprise 2.0 usually appeared at the beginning of the remarks as a meagre reference to the need for adequate corporate culture and organisational conditions" (Kopp 2011, p. 39). Nevertheless, it was precisely the rare successful models of Enterprise 2.0 at that time which underlined the need to make social innovation instead of technologies the focus of adequate reorganisation measures. As the results of our research project on advanced innovation approaches in the high-tech sector show, in some enterprises the conversion of "Enterprise 1.0" into "Enterprise 2.0" at first took place "almost entirely without the assistance of Web 2.0 tools such as wikis, forums and other social media" (Stamer

2008, p. 74). The key difference lies in the nature and scope of successful self-organisation that an enterprise enables. Whereas Enterprise 1.0 (in the textbook case) is distinguished by hierarchical structures and processes intended to improve its own performance, with Enterprise 2.0 precisely the opposite strategy is pursued: in many places, hierarchies are deliberately dismantled to create the necessary space for successful self-organisation. Any such functioning self-organisation should give rise to a permanent innovation dynamic and creativity. Thus, if there is such a thing as a guiding theme for the transformation into an Enterprise 2.0, it is 'the art of letting go'" (ibid., p. 61). These thoughts correspond to a specific understanding of socio-technical system design, in which it is not technology that brings about organisational change. Reference to the socio-technical system approach dating from the 1960s underlines the close relationship between technological and social subsystems. Emery, Thorsrud and Trist describe the basic idea with the statement: "In general, management must recognise that that the success of an enterprise depends upon how it works as a socio-technical system, not simply as a technical system with replaceable individuals added to fit" (Emery et al. 1969, p. 85).

According to Schelske, "socio-technical theories of sociology assume that the social and economic determining factors predominate when it comes to explaining social change viewed together with information technology" (Schelske 2007, p. 7). However, the use of modern digital technology also marks a significant shift in perspective: or "media-history break" (Münkler 2009, p. 62), with far-reaching consequences for the dynamics of socio-technical configurations. Digital technology enables incomparably more degrees of freedom in the social system than was conceivable in the context of conventional technologies. As a result, the importance of the social realm in social-technical system design increases massively. As Münkler explains, the historically correct thesis according to which the (technical) materiality of media preforms or determines their use, proves to be outdated. Thus modern digital media determine their own use to a much lesser extent than previous technologies did. More than ever, it is the social practices of users and their usage behaviour that configure the new technologies according to needs, and thus assign their purpose. "Digital media do not determine their use; digital media are created through their use" (Münkler 2009, p. 27). In the production sector too, for ever more activities, digital informationisation means a "rapid increase in the potential for design" (Pfeiffer 2010, p. 252). Against this backdrop, the example of Enterprise 2.0 represents a transformation from the socio-technical system approach to the socio-digital innovation system. Socio-digital innovation systems refer to a mix of new organisation and management concepts (learning organisation, knowledge management, network management, scrum) and their modern technological "enablers" from the Web 2.0 repertoire (cf. Kopp 2011). In other words, the narrowing of Enterprise 2.0 to Web 2.0 first had to be overcome in favour of a more comprehensive socio-technical or socio-digital perspective, before it could be successfully implemented in enterprises.

Back to the future with Industry 4.0?

Given how valuable early assessments of possible change trends and design challenges are, assuming a wider diffusion of Industry 4.0, and with regard to the work-related consequences, it seems all the more important to us to emphasise positions that tend to be marginalised in the discourse. These positions highlight the fundamental weaknesses of Industry 4.0 (degree of innovation, reach and risks), and it can be pointed out that alternatives to the current vision of Industry 4.0 are conceivable and definitely present. Even the most fervent advocates of Industry 4.0 concede that despite the existence of the first demonstration systems, very long development periods can still be expected (cf. Kagermann 2012, p. 12). Yet, as Bornemann

notes, technological developments below the aimed-for level of highly complex simultaneous control cannot claim to be particularly innovative (cf. Bornemann 2014). Moreover, the vision of Industry 4.0 is accompanied by considerable risks. Apart from unresolved security issues, it is still too early to tell whether it will be possible to master control over the necessary volumes of data (big data). One Achilles' heel is that a "world language" for machines needs to be created. "Unless there is agreement on one or at least a few industry-wide standards, the entire vision of intelligent production could disappear in a Tower of Babel scenario" (Eisert 2014, p. 5). Expectations regarding the extent of exploitable productivity reserves are also rather unclear. The German National Academy of Science and Engineering (acatech) "estimates that businesses could boost their productivity by 30 percent with Industry 4.0. No-one today can say how realistic these figures are" (Eisert 2014, p. 1). Given the problems and risks outlined above, it is not surprising that the response of businesses: especially small and medium-sized businesses, to the apparent attractions of Industry 4.0 has been lukewarm at best (cf. Tauber 2014).

Probably the greatest risk is that the underlying, strongly technology-oriented innovation approach is not capable of appropriately developing the potentials of digital technology. The fundamental doubts expressed by management consulting firm Arthur D. Little also point towards a preference for integrated innovation approaches: "But the battle of the future will be won on other fields and likely also with other innovation approaches" (2013, n.p.) That, at least, is according to an analyst's statement in a press release from Arthur D. Little. They hold Industry 4.0 to be too product-oriented. In contrast, they say, integrated innovation approaches are more important for the competitiveness of economies. As the example of the automotive industry shows, these consist of "combinations of new mobility concepts, product features, business models and marketing" (ibid.) Another plea for a more comprehensive innovation concept can be found in the "Connected reality 2025" trend study by Z_punkt, which argues that system innovations should help solve social problems. "But [these] cannot be developed and implemented by individual actors. They require partnerships, development alliances and thinking in complex value creation patterns, which a purely technological innovation logic must be subordinate to" (Boeing et al. 2014, p. 55). Greater sensitivity to the need for co-operation between all kinds of stakeholders in the innovation process is characteristic of the new innovation paradigm. In the Digital Agenda for Europe, this concept of open innovation is currently associated with the "quadruple helix model" (cf. Dhondt & Oeij 2014, p. 139; Carayannis & Campbell 2011). Here it states: "Open Innovation is an important component of the foreseen European Innovation System, where all stakeholders need to be involved and create seamless interaction and mash-up for ideas in innovation ecosystem. […] Open Innovation 2.0 (OI2) is a new paradigm based on a **Quadruple Helix Model** where government, industry, academia and civil participants work together to co-create the future and drive structural changes far beyond the scope of what any one organisation or person could do alone. This model encompasses also user-oriented innovation models to take full advantage of cross-fertilisation of ideas leading to experimentation and prototyping in real world setting" (Digital Agenda for Europe, no date). At the level of enterprises, it is concepts such as Workplace Innovation[1] which aim for comprehensive

1 An overview of the concept and its importance for the innovative capacity of modern societies can be found in the Dortmund/Brussels position paper, which offers the following definition: "*Workplace innovation* is a social, participatory process which shapes work organisation and working life, combining their human, organisational and technological dimensions. This participatory process simultaneously results in improved organisational performance and enhanced quality of working life." (cf. Dortmund/Brussels paper, p. 1). The initiative is now being promoted by the European network EUWIN.

utilisation of the potentials of human labour as a condition for ensuring innovative ability, and correspond to the outlined alternate innovation orientation (cf. Howaldt et al. 2012; Totterdill 2012). In the context of the discussion about social innovation, management and business literature over many years formed a major research focus. “In this literature, emphasis is put on the role of ‘improvements’ in social capital which can subsequently lead to better-working (more effective or efficient) organisations in the economy, and thereby generate positive effects in terms of social innovation across the sector” (Moulaert et al. 2005, pp. 73 ff.; cf. also Brooks 1982 and Kesselring & Leitner 2008). Germany: against a background of funding programmes such as “humanising work”, “work and technology”, “innovative workplace design and the future of work”, has built up a wealth of experience which, at the same time, constitutes an important competitive advantage internationally (cf. Georg et al. 2012). These programmes were guided from an early stage by the idea of a comprehensive innovation concept. In their analyses of the complex relationships between social and technological innovation processes in enterprises, they provided vital input for a comprehensive understanding of innovation, and developed new strategies, concepts and instruments which have enabled businesses and intermediary actors to compete successfully in the international arena (cf. e.g. the articles in Ludwig et al. 2007; Streich & Wahl 2007; Gatermann & Fleck 2010; and Jostmeier et al. 2014). In the international innovation debate, the orientation towards enterprises and employees is still an unusual feature.

It is therefore logical that the “innovative working environment” theme occupies an important position in the German federal government’s new high-tech strategy. “New forms of work organisation, stronger service focus, changing skills and job profiles, more interactive value creation processes and increasing digitalisation: all these are driving forces of the far-reaching change that the modern working world is undergoing. Today more than ever, being innovative requires complex processes that need interaction with technological development, but also with human resource, organisational and skills development. ‘Good work’ is therefore an important basis for business innovations” (BMBF 2014, p. 22). It seems questionable whether national go-it-alone efforts can succeed in developing internationally competitive platforms quickly enough, but that is beyond the scope of this discussion. In their lack of European co-ordination, the large number of different approaches in European countries brings to mind the situation with regard to Industry 4.0. However, the European Workplace Innovation Network (EUWIN) has started to actively address this, and is attempting to develop common standards with its Workplace Innovation approach. Pot and Dhondt describe the origins of the Workplace Innovation approach like this: “Workplace Innovation, as it developed from the beginning of this century has its roots in sociotechnical systems design (STSD), going back to the restructuring of Europe after the Second World War, starting campaigns for productivity and industrial democracy” (ibid.) Peter Totterdill, one of the leading exponents of the approach, points out that the requirements for Workplace Innovation include quality of work, participation and decentralisation, and goes on to state: “Most importantly, Workplace Innovation is an inherently social process. It seeks to build bridges between the strategic knowledge of the leadership, the professional and tacit knowledge of frontline employees, and the organisational design knowledge of experts. […] Thus in defining Workplace Innovation it is important to recognise both process and outcomes.” (Totterdill 2015, p. 57) The dual practical benefit of corresponding socio-technical/socio-digital system designs: firstly the improvement in motivation, job satisfaction and employee well-being, secondly the improvement in performance, has also been repeatedly confirmed by research (for a current example, cf. Ramstad 2014). Thus there are many good reasons to emphasise the importance of this perspective and, even in the context of digital manufacturing concepts, to put the job and employees’ potential at the centre of considerations, instead of neglecting this in favour of

a one-sided technology-oriented perspective. A knowledge-based economy, as a prerequisite for maintaining and enhancing the competitiveness of German and European businesses, is inconceivable without the development of management concepts and business structures that promote innovation. “European economies are facing a period of economic crises and there is a political urgency for continuous innovation and growth in productivity in order to realise sustainable growth and welfare provision within the European Union (EU). To achieve this aim, it is not sufficient just to introduce new technologies […]. It will require the full utilisation of the potential workforce and creation of flexible work organisations” (Pot et al. 2012, p. 261). At European level, this approach has now become an integral part of the policies of the Directorate-General (DG) GROWTH (industrial policy, innovation policy) and the DG Employment (competence development, quality jobs) (cf. Pot & Dhondt 2015).

Conclusion

In view of the growing importance of new technologies in our working and everyday lives, it is hardly surprising that technology-driven utopias such as Halle 54, Enterprise 2.0 and currently the debate surrounding Industry 4.0 attract a lot of attention: especially when they are purposely promoted by influential actors. And yet a look back into the past should make us aware that it is only by analysing the complex interplay between social and technological innovations that we arrive at a realistic vision of the future, which can guide us in designing forward-looking production and work systems. “Anyone who wants Industry 4.0 should critically examine the ‘high-tech obsession’” and “should regard it primarily as a social innovation” (Buhr 2015, pp. 19 f.) This designing takes place in enterprises and organisations, and in the future too will be influenced by a realistic view of the relationships between technical, organisational and human resource aspects. Deuse et al. emphasise the point: “Experiences from the past clearly show that neither distinctly technology-centred nor human-centred design paradigms contribute to a sustained and clear improvement in competitiveness, but rather that under some circumstances they may even have a negative impact. In contrast, organisation-centred approaches to designing production systems have achieved significant progress in improving competitiveness. The hypothesis states that the success of the proclaimed fourth industrial revolution depends crucially on whether it is sustainably anchored in the organisation and implemented in a targeted way. Accordingly, human and technological aspects should be adapted to and aligned with the organisation’s structures and processes” (Deuse et al. 2014, p. 44).

In Germany, the new Industry 4.0 dialogue platform, which was launched in April 2015 under the supervision of the German federal economics ministry, aims to stimulate Industry 4.0 activities. It is to be hoped that the approaches contained in the white paper on research and development themes for Industry 4.0 (2015) regarding the giving of greater consideration to participative working cultures will receive greater emphasis (p. 11). A participation-based understanding of socio-technical systems and design is to serve as a foundation for the development steps towards Industry 4.0 (cf. p. 31). Thus the white paper continues: “It is essential for the acceptance, potential for achievement and development, well-being and health of working people that activity and task structures are geared to these goals. Relevant criteria include, for example, that planning, organising, implementing and monitoring tasks are integrated into a job’s work activities, and that there is an appropriate balance between undemanding routine tasks and more challenging tasks such as problem-solving. Work equipment that is conducive to learning should support a work organisation that promotes learning” (p. 31).

Today, a society's ability to exploit and systematically develop existing innovation potential increasingly determines its future sustainability. The underlying understanding of innovation is crucial for the full development of technological potentials and their integration into sustainable development processes. Strongly technology-driven concepts of the past (cf. "Halle 54", "Enterprise 2.0") had considerable implementation problems requiring drastic changes of course, which shows that the desired benefits expected by diverse groups of actors only materialised as a result of extensive work-oriented corrections. A wider perspective implies not so much taking additional (social) aspects into account, but rather sets significantly different emphases in tackling social challenges. Rather than promoting a "technological push" and its subsequent socially acceptable design, the focus shifts to enhancing innovative capacity by involving social actors in the development of solutions for the future. At the level of enterprises and organisation, this is a question of integrated socio-technical management approaches, as are combined for example in international work and management research in the Workplace Innovation approach. The new high-tech strategy for Germany, with its emphasis on the need for an innovative working environment, also shows that such ideas have made an impact, and it therefore ties in with the discussion about a changed understanding of innovation. New programmes launched by the German Federal Ministry of Education and Research (BMBF), the German Federal Ministry for Economic Affairs and Energy (BMWi), and also programmes by German states such as the North Rhine-Westphalia lead market competition for the digital working environment and future of work, provide scope for joint activities between academia and practitioners to develop participative management forms as well as new innovation approaches. A characteristic of hypes and management fads is that they are relatively short-lived. As the initial, still undiminished euphoria surrounding Industry 4.0 dies down, the outlined alternatives will become considerably more important once again.

References

Arthur D. Little 2013: Zur Zukunft von "Industrie 4.0". Internet: http://www.adlittle.de/bempressemeldungen_de.html?&no_cache=1&view=447 (accessed on 27 February 2015)

Back A & Heidecke F. 2009: Einleitung. In: Back A., Gronau N.& Tochtermann, K. (eds.): Web 2.0 in der Unternehmenspraxis. Grundlagen, Fallstudien und Trends zum Einsatz von Social Software. 2nd updated edition. Munich, pp. 1-8

Bauer W., Schlundt S., Marrenbach D., & Ganschar O. (2014): Industrie 4.0 – Volkswirtschaftliches Potenzial für Deutschland. Studie. Berlin/Stuttgart. Internet: http://www.bitkom.org/de/themen/74736_79154.aspx (accessed on 30 March 2015)

Becker K.-D. 2014: Positionen der Sozialpartner. Arbeit in der Industrie 4.0 – Erwartungen des Instituts für Angewandte Arbeitswissenschaft e.V. In: Bundesministerium für Wirtschaft und Energie (ed.): Zukunft der Arbeit in Industrie 4.0, Berlin, pp. 15-18

Boeing N., Burmeister K., Neef A., Rodenhäuser B. & Schroll W. 2014: ConnectedReality 2025. Die nächste Welle der digitalen Transformation. Internet: http://www.z-punkt.de/connected-reality2025.html (accessed on 9 February 2015)

Bornemann D. 2014: "Industrie 4.0". Vermessen und funktional – aber nicht revolutionär. Managerkreis der Friedrich Ebert Stiftung. Impulse Wirtschaft und Politik (Oktober). Internet: http://library.fes.de/pdf-files/managerkreis/10975.pdf (accessed on 8 November 2014)

Botthof A. & Hartmann E.A. (eds.) 2015: Zukunft der Arbeit in "Industrie 4.0". Berlin/Heidelberg

Brooks H. 1982: Social and technological innovation. In: Lundstedt S. B. & Dolglazier E.W . (eds): Managing innovation. Elmsford, New York, pp. 9-10

Bullinger H.-J. 2006: Verdammt zur Innovation. In: RKW-Magazin, 57, pp. 12-14

Bundesministerium für Bildung und Forschung (BMBF) 2014 (ed.): Die neue Hightech-Strategie. Innovationen für Deutschland. Internet: http://www.bmbf.de/pub_hts/HTS_Broschure_Web.pdf (accessed on 10 February 2015)

Buhr N. 2015: Soziale Innovationspolitik für die Industrie 4.0. Expertise im Auftrag der Abteilung Wirtschafts- und Sozialpolitik der Friedrich-Ebert-Stiftung. Bonn

Carayannis E.G. & Campbell D. F. J. 2009: 'Mode 3' and Quadruple Helix': toward a 21st century fractal innovation eco system. In: Internationale Zeitschrift für Technologiemanagement, vol. 46 (2009), no. 3-4, pp. 201-234

Chesbrough H.W. (2003): Open Innovation: The New Imperative for Creating and Profiting from Technology. Boston

Deuse J., Kirsten W., Hengstebeck A. & Busch F. 2014: Gestaltung von Produktionssystemen im Kontext von Industrie 4.0. In: Bundesministerium für Wirtschaft und Energie (ed.): Zukunft der Arbeit in Industrie 4.0, Berlin, pp. 43-49. Internet: http://www.bmwi.de/BMWi/Redaktion/PDF/Publikationen/zukunft-der-arbeit-in-industrie-4-0,property=pdf,bereich=bmwi2012,sprache=de,rwb=true.pdf (accessed on 27 February 2015)

Digitale Agenda for Europe (n.d.): Open Innovation. Internet: https://ec.europa.eu/digital-agenda/open-innovation-20 (accessed on 10 February 2015)

Dhondt S. & Oeij P. 2014: Social Innovation related to innovation in Management Studies. In: Howaldt J., Butzin A., Domanski D. & Kaletka C. (eds.) 2014: Theoretical Approaches to Social Innovation – A Critical Literature Review. A deliverable of the project: "Social Innovation: Driving Force of Social Change" (SI-DRIVE). Dortmund: Sozialforschungsstelle, pp. 122-150

Dortmund/Brussels Position Paper 2012: Workplace Innovation as Social Innovation: Internet: http://ec.europa.eu/enterprise/policies/innovation/files/dortmund-brussels-position-paper-workplace-innovation_en.pdf (accessed on 2 March 2015)

Eisert R. 2014: "Industrie 4.0". Gebt den Maschinen das Kommando. In: Wirtschaftswoche dated 13 March 2014. Internet: http://www.wiwo.de/technologie/cebit-spezial/industrie-4-0-gebt-den-maschinen-das- kommando/9594706.html (accessed on 8 November 2014)

Emery F.E., Thorsrud E. & Trist E. 1969: Form and Content in Industrial Democracy. London/Tavistock

FORA 2010: New Nature of Innovation. Report to the OECD. Copenhagen

Fraunhofer IAO 2015: Patentanalyse des Fraunhofer IAO zeigt Chinas Vorsprung im Bereich Industrie 4.0. Internet: http://www.iao.fraunhofer.de/lang-de/geschaeftsfelder/technologie-und-innovationsmanagement/1503-industrie-4-0-china-auf-der-ueberholspur.html (accessed on 24 June 2015)

Gatermann I. & Fleck M. (eds.) 2010: Innovationsfähigkeit sichert Zukunft. Beiträge zum 2. Zukunftsforum des BMBF. Berlin

Georg A,. Hasselkuss M., Howaldt J., Jacobsen H. And Jostmeier, M. 2012: Arbeitsforschung für Innovationsprozesse. Ergebnisse und Folgerungen aus der Arbeit des BMBF-Förderschwerpunkts "Innovationsstrategien jenseits traditionellen Managements". Dortmund

Gillwald K. 2000: Konzepte sozialer Innovation. Edited by Querschnittsgruppe Arbeit und Ökologie. Wissenschaftszentrum Berlin für Sozialforschung. Internet: http://bibliothek.wzb.eu/pdf/2000/p00-519.pdf (accessed on 27 February 2015)

Hack L. 1994: Industriesoziologie. In: Kerber H. & Schmieder A. (eds.), Spezielle Soziologien. Problemfelder, Forschungsbereiche, Anwendungsorientierungen. Hamburg, pp. 40-74

Hartmann E. 2014: Arbeitsgestaltung für Industrie 4.0: Alte Wahrheiten, neue Herausforderungen. In: Bundesministerium für Wirtschaft und Energie (ed.): Zukunft der Arbeit in Industrie 4.0, Berlin, pp. 7-14.

Internet:http://www.bmwi.de/BMWi/Redaktion/PDF/Publikationen/zukunft-der-arbeit-in-industrie-4-0,property=pdf,bereich=bmwi2012,sprache=de,rwb=true.pdf (accessed on 27 February 2015)

Heßler M. 2014: Die Halle 54 bei Volkswagen und die Grenzen der Automatisierung. Überlegungen zum Mensch-Maschine-Verhältnis in der industriellen Produktion der 1980er Jahre. Zeithistorische Forschungen 1/2014: Offenes Heft. Internet: http://www.zeithistorische-forschungen.de/1-2014/id%3D4996 (accessed on 9 April 2015)

Hirsch-Kreinsen H. 2014: Wandel von Produktionsarbeit – Industrie 4.0. In: WSI Mitteilungen 6/2014

Howaldt J. & Kopp R. 2015: Industrie 4.0 und die Zukunft der Arbeit. Frankfurter Allgemeine Zeitung, Sonderveröffentlichung NRW, Spitzenstandort für Industrie 4.0, published 10 April 2015, p. V6

Howaldt H., Kopp R. & Flocken P. (eds.) 2001: Kooperationsverbünde und regionale Modernisierung – Theorie und Praxis der Netzwerkarbeit. Wiesbaden/Germany

Howaldt J., Kopp R. & Pot F. 2012: Workplace Innovation for Better Jobs and Performance – The Most Important Development in Modern Working Environments. In: Jeschke, S., Hees F., Richert A. & Trantow S. (eds.): Prethinking Work. Insights on the Future of Work, Münster, pp. 71-72

Howaldt J. & Schwarz M. 2010: Soziale Innovation. Skizze eines gesellschaftstheoretisch inspirierten Forschungskonzepts. Bielefeld

IG Metall NRW 2013: Industriearbeit 4.0. die Zukunft mitgestalten. Fachkonferenz zur Industriearbeit 4.0 in Paderborn. Düsseldorf/Germany http://www.igmetall-nrw.de/uploads/media/2014_04_04_Industrie4.0.pdf (accessed on 3 January 2014)

Jacobsen H. 2005: Produktion und Konsumtion von Dienstleistungen: Konsumenten zwischen Innovation und Rationalisierung. In: Jacobsen H. & Voswinkel S. (eds.): Der Kunde in der Dienstleistungsbeziehung.Wiesbaden, pp. 15-36

Jostmeier M., Georg, A. & Jacobsen, H. (eds.): Sozialen Wandel gestalten. Zum gesellschaftlichen Innovationspotenzial von Arbeits- und Organisationsforschung, Dortmunder Beiträge zur Sozialforschung. Wiesbaden/Germany

Kagermann H. 2012: Die vierte industrielle Revolution. In: Zukunftsmanager, vol. 3 (2012), pp. 4-8

Kagermann H., Wahlster, W., & Helbig, J. (eds.) 2013: Deutschlands Zukunft als Produktionsstandort sichern. Umsetzungsempfehlungen für das Zukunftsprojekt Industrie 4.0. Abschlussbericht des Arbeitskreises Industrie 4.0. Frankfurt. Internet: http://www.bmbf.de/pubRD/Umsetzungsempfehlungen_Industrie4_0.pdf (accessed on 5 March 2015)

Kärcher B. 2014: Erfahrungen und Herausforderungen in der Industrie. Alternative Wege in die Industrie 4.0 – Möglichkeiten und Grenzen. In: Bundesministerium für Wirtschaft und Energie (ed.): Zukunft der Arbeit in Industrie 4.0, Berlin, pp. 19-25. Internet: http://www.bmwi.de/BMWi/Redaktion/PDF/Publikationen/zukunft-der-arbeit-in-industrie-4-0,property=pdf,bereich=bmwi2012,sprache=de,rwb=true.pdf (accessed on 27 February 2015)

Kern H. & Schumann M. 1984: Das Ende der Arbeitsteilung? Rationalisierung in der industriellen Produktion. Munich

Kern H.& Schumann M. 1970: Industriearbeit und Arbeierbewußtsein, Frankfurt a.M.

Kesselring A. & Leitner, M. 2008: Soziale Innovationen in Unternehmen. Erstellt im Auftrag der Unruhe Stiftung. Internet:

https://www.zsi.at/attach/1Soziale_Innovation_in_Unternehmen_ENDBERICHT.pdf (accessed on 27 February 2015)

Kieser A. 1996: Moden und Mythen des Organisierens. In: DBW 56, vol. 1, pp. 21-39

Koch M.& Richter A. 2009: Enterprise 2.0. Erfahrung , Einführung und erfolgreicher Einsatz von Social Software in Unternehmen. Munich

Kopp R. 2011: Enterprise 2.0 als soziodigitales Innovationssystem. In: Howaldt J., Kopp R. & Beerheide E. (eds.): Innovationsmanagement 2.0. Handlungsorientierte Einführung und praxisbasierte Impulse. Wiesbaden, pp. 37-65

Ludwig J., Moldaschl M., Schmauder M.& Schmierl K. (eds.) 2007: Arbeitsforschung und Innovationsfähigkeit in Deutschland. Munich/Mering

Lutz B. 1987: Das Ende des Technikdeterminismus und die Folgen. Soziologische Technikforschung vor neuen Aufgaben und Problemen. In: Lutz B. (ed.): Technik und sozialer Wandel. Verhandlungen des 23. Deutschen Soziologentages in Hamburg 1986, Frankfurt a. M., pp. 34-52

McAfee A. 2006: Enterprise 2.0, Version 2.0. Internet:

http://andrewmcafee.org/2006/09/enterprise_20_inclusionists_and_deletionists/ (accessed on 1 February 2015)

Minssen H., Howaldt J.& Kopp R. 1991: Gruppenarbeit in der Automobilindustrie – Das Beispiel Opel Bochum. In: WSI-Mitteilungen, vol. 7 (1991), pp. 434-441

Moulaert F., Martinelli F., Swyngedouw E., Gonzalez S. 2005: Towards Alternative Model(s) of Local Innovation. In: Urban Studies 42 (11), pp. 1669-1990

Münkler S. 2009: Emergenz digitaler Öffentlichkeiten. Die sozialen Medien im Web 2.0. Frankfurt

MTM aktuell 2014: Industrie 4.0 ist machbar, der Mensch 4.0 nicht ohne weiteres. MTM-Bundestagung zu den Perspektiven des Industrial Engineering in der Arbeitswelt von morgen. MTM aktuell, pp. 4-6

Pfeiffer S. 2010: Technisierung von Arbeit. In: Böhle F., Voß, G. & Wachtler, G. (eds.): Handbuch Arbeitssoziologie. Wiesbaden, pp. 231-262

Plattform Industrie 4.0 2015: Industrie 4.0 Whitepaper FuE-Themen, 7. April 2015. Internet: https://www.google.de/search?q=Industrie+4.0+Whitepaper+FuE-Themen+7.+April&ie=utf-8&oe=utf-8&aq=t&rls=org.mozilla:de:official&client=firefox-a&gfe_rd=cr&ei=hnnIVY6xPKuA8Qf8gKXYDg (accessed on 24 June 2015)

Pot F. & Dhondt S. forthcoming 2015: Workplace Innovation. In: Mohr B.& Van Amelsvoort, P. (eds.): Co-creating humane and innovative communities of work: The Evolution of STS Design Practice and Perspective

Pot F., Dhondt S. & Oeij P. 2012. Social innovation of work and employment. In: Franz H.-W., Hochgerner J. & Howaldt, J. (eds.): Challenge Social Innovation. Potential for business, social entrepreneurship, welfare and civil society. Berlin, pp. 261-274

Ramstad E. 2014: Can High-involvement Innovation Practices improve Productivity and the Quality of Working-life simultaneously? Management and Employee. In: Nordic Journal of Working Life Studies 4, (4), December 2014

Schelske A. 2007: Soziologie vernetzter Medien. Grundlagen computervermittelter Vergesellschaftung. Oldenbourg/Munich/Vienna

SMLC – Smart Manufacturing Leadership Coalition 2011: Implementing 21st Century Smart Manufacturing. Workshop Summary Report. Internet: https://smartmanufacturingcoalition.org/implementing-21st-century-smart-manufacturing (accessed on 24 June 2015)

Stamer S. 2008: Enterprise 2.0 – Learning By Doing. In: Buhse W.& Stamer S. (eds.): Enterprise 2.0 – Die Kunst, loszulassen. Berlin , pp. 59-87

Streich D.& Wahl D. (eds.) 2007: Innovationsfähigkeit in einer modernen Arbeitswelt. Personalentwicklung – Organisationsentwicklung – Kompetenzentwicklung. Beiträge der Tagung des BMBF. Frankfurt a. M./New York

Tauber A. 2014: Warten auf die vierte industrielle Revolution. In: Die Welt, 10 September 2014

Totterdill P. 2015: Closing the Gap: The Fifth Element and Workplace Innovation. In: European Journal Of Workplace Innovation, vol. 1, no. 1, pp. 55-74; Internet: http://journal.uia.no/index.php/EJWI/article/view/166/113 (accessed on 27 February 2015)

Totterdill P., Cressey P. & Exton R. 2012: Social innovation at work: workplace innovation as a social process. In: Franz H.-W., Hochgerner J. & Howaldt J. (eds.) Challenge Social Innovation. Potential for business, social entrepreneurship, welfare and civil society. Berlin, pp. 241-259

Totterdill P. 2013: The future we want? Work and Organisations in 2020. A Report by the Advisory Board of the UK Work Organisation Network. Internet: http://www.google.de/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0CCUQFjAA&url=http%3A%2F%2Fuk.ukwon.eu%2F_literature_1812%2FUKWON_2020_Report&ei=wnL0VKXkG8HcUq2jgYAB&usg=AFQjCNFB-lXXcZVtLFPe-ZGfmNvWN3b4Tw&bvm=bv.87269000,d.d24&cad=rja (accessed on 2 March 2015)

Wischmann S. 2014: Arbeitssystemgestaltung im Spannungsfeld zwischen Organisation und Mensch-Technik-Interaktion – das Beispiel Robotik. In: Bundesministerium für Wirtschaft und Energie (ed.): Zukunft der Arbeit in Industrie 4.0, Berlin, pp. 72-77. Internet: http://www.bmwi.de/BMWi/Redaktion/PDF/Publikationen/zukunft-der-arbeit-in-industrie-4-0,property=pdf,bereich=bmwi2012,sprache=de,rwb=true.pdf (accessed on 27 February 2015)

About the authors

Ralf Kopp

Research associate at Sozialforschungsstelle Dortmund (sfs), Central Scientific Institute of TU Dortmund. Main research focuses: network and innovation management, organisational development, social innovations.

Germany

Email: Kopp@sfs-dortmund.de

Jürgen Howaldt

Director of Sozialforschungsstelle Dortmund (sfs), Central Scientific Institute of TU Dortmund. Main research focuses: new management concepts, organisational development and consulting, social sciences-based innovation research

Germany

Email: Howaldt@sfs-dortmund.de

Jürgen Schultze

Research associate at Sozialforschungsstelle Dortmund (sfs), Central Scientific Institute of TU Dortmund. Main research focuses: organisational development, comprehensive innovation dialogues, importance of social innovations for sustainability

Germany

Email: Schultze@sfs-dortmund.de