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Inhalt

Abstract

This contribution deals with the ongoing discourse about the new quality, perspectives and social consequences of the application of today's digital technologies. It focuses primarily on the German situation. The basic perspective of the German discourse is that new potential applications of digital technologies are opening fully new forms of production and marketing of industrial goods, so that it should now be possible to speak of a foreseeable "Fourth Industrial Revolution", also referred to as "Industry 4.0".

The contribution asks about the *conditions for the preconditions for the genesis and development of the discourse on Industry 4.0. Three theses are discussed:

- First, Industry 4.0 has the character of a "promising technology" based on the premise that advances in digital technologies will bring about new and positive technological, economic and social advantages. This is the point of reference for the expectations and coordinated activities of heterogeneous actors.

- Second, the precondition for this is a semantic architecture of the promising technology that engenders through a generalizing rhetoric a high degree of societal acceptance of the Industry 4.0 discourse.

- Third, the technological promise has an ambivalent character. On the one hand it exhibits the character of a techno-utopia with its far-reaching generalization. On the other hand, this discourse has provoked increasingly skeptical and critical positions emphasizing social risks and negative social consequences.

Finally, the expectation is formulated that the Industry 4.0 discourse foreseeably will take the path of a typical technological "hype cycle".

1. Introductory remarks[1]

The label "Industry 4.0" has intensively characterized for several years the German debate over the future of the industrial sector. Also under this label a great number of R&D, industry, research and policy measures have been initiated in the meantime. The programmatic publications issuing from these initiatives, as well as conferences, congresses and expositions on the topic are now so many as to hardly permit any concise overview. The basic perspective of this discourse is that new potential applications of digital technologies are opening fully new forms of production and marketing of industrial goods, so that it should now be possible to speak of a foreseeable "fourth industrial revolution". This discourse is also occurring in the context of the international debate over the new qualities, perspectives and consequences of the application of today's digital technologies — also called by some the "second machine age", or the "internet of things" (Brynjolfsson and McAfee, 2014; Bullinger and ten Hompel, 2007). At the same time it exhibits, with its dominant focus on industrial processes, a German national-specific character. In view of the intensity of the debate and the public resonance around this theme in Germany, the question is becoming nothing less than urgent whether we are dealing not only with a new technological "hype", but also with an actual societal mega-trend.

The following argumentation will refer primarily to the German debate on Industry 4.0, while exploring the international dimension of the digitization debate rather only marginally and comparatively. The aim will be to shed light to some extent on the increasingly intensive discourse of recent years about Industry 4.0 in regard to the conditions that engendered it and the perspectives for its development, as well as to estimate its foreseeable scope. The following three theses are the point of departure for this:

- First, Industry 4.0 has the character of a "promising technology", based on the premise that advances in digital technologies will bring about new and positive technological, economic and social prospects. That promise is the point of reference for expectations and coordinated activities of heterogeneous actors.

[1] This paper is a clearly revised version of a German-language text first published under the title "Industrie 4.0 als Technologieversprechen" (Hirsch-Kreinsen, 2016).

- Second, the precondition for this is a semantic architecture of the promising technology that engenders through a generalizing rhetoric a high degree of societal acceptance of the Industry 4.0 discourse.

- Third, the technological promise has an ambivalent character. On the one hand with its far-reaching generalization it shows a character of a techno-utopia. *On the other hand, it exhibits the character of a techno-utopia with its far-reaching generalization. Paradoxically, on the other hand reacting to this discourse are increasingly skeptical and critical positions that warn of serious negative social risks and consequences.

Finally, the expectation is formulated that the Industry 4.0 discourse will foreseeably take the path of a typical technological "hype cycle".

The empirical basis of the following argumentation is, for one, information gathered for many years over the course of ongoing observations of the Industry 4.0 discussion at the most various levels of politics and in enterprises. For another thing, the arguments are supported by assessments of documents and Internet sources on the Industry 4.0 discourse, a wider and ongoing literature research, as well as on empirical findings of ongoing research projects on Industry 4.0.

2. On the emergence of the "Industry 4.0" discourse

To substantiate the first thesis of "Industry 4.0" as "promising technology" one can refer to an identical concept from sociological innovation research. This concept — also going by the label of the "sociology of expectations" — asks what the coordination mechanisms are between heterogeneous actors in the course of technology development, and what the constitutive conditions are for the emergence of new technology fields (e.g. van Lente, 1993; van Lente and Rip, 1998; Bender, 2005; Borup et al., 2006; Hahn, 2013). The advocates of this concept have elaborated a model of technology development that posits the process of an increasingly more stable reciprocal effect between the emergence of social orders and the ever-greater preciseness of the perceptions of technological development (Bender, 2005: 173).

The concept can be roughly divided analytically into three sequential process steps. First, the formulation of programmatic *development perspectives*, called an *expectation statement*; second, the project of a *collective agenda* which increasingly structures the actions of participating and interested actors; and third, this interaction context solidifies gradually

into a relatively *stable action-context* with a specific new logic and level of normative commitment. If the Industry 4.0 discourse is analyzed within this conceptual framework, the following steps and sub-steps can be differentiated.

2.1 Expectation statement

Point of departure of the current Industry 4.0 discourse was a projection of future economic development which predicted the technologically grounded potentials as well as far-reaching societal transformations. This projection was first presented to a larger audience during the Hannover Messe in the spring of 2011. The originators of this concept[2] heralded an industrial "paradigm shift" for Germany on the basis of new digital technologies that must be realized without delay. This projection insists that industrial development is currently on the threshold of nothing less than a new, "fourth industrial revolution" driven by the dramatically developing application possibilities of digital and intelligent production technologies. As the urgent reason for this they insist that Germany must be able to assert itself as a production site in a high-wage region and ensure its global competitiveness. On their arguments, manufacturing costs can be reduced despite individualized manufacturing. Networking the companies in the supply chain makes it possible to optimize not only individual production steps, but the entire value chain. Comprehensive realtime information enables companies to react to the availability of certain raw materials early on, for example. Production processes can be controlled across company boundaries to save resources and energy. The originators underscore that with Industry 4.0 production flexibility and efficiency can be improved and thereby the competitiveness of German industry strengthened (Kagermann et al., 2011) (Fig. 1). This position statement had been preceded by a recommendation of the central innovation-policy advisory committee of the German government, the *Forschungsunion Wirtschaft-Wissenschaft* at the beginning of 2011, to promote a *Zukunftsprojekt Industrie 4.0* ("Project for a future Industry 4.0") within the framework of their innovation policy on "high-tech strategy" (Forschungsunion, 2012).

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[2] The President of the German National Academy of Science and Engineering Henning Kagermann, the computer scientist Wolfgang Wahlster, and Wolf-Dieter Lukas, a high-level political actor at the German Ministry of Education and Research.

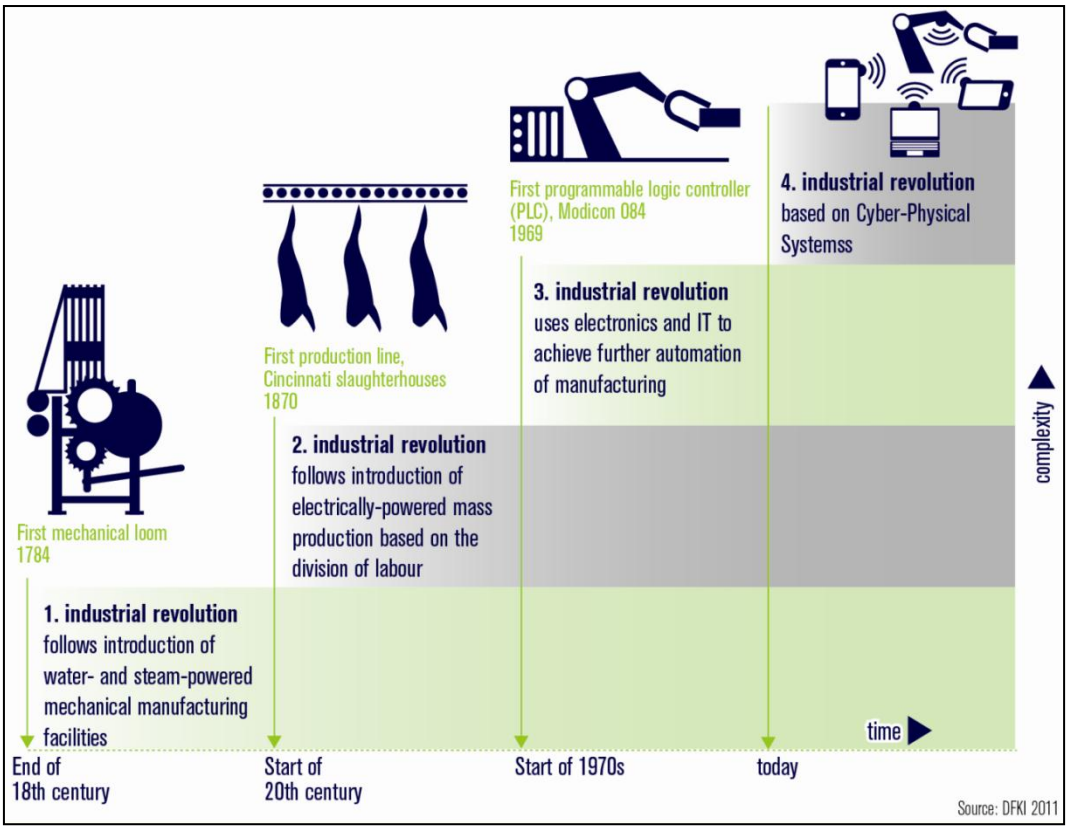

Figure 1. The vision of "Industry 4.0" (source: DFKI)

Under the label "Industry 4.0" a future scenario was projected that predicted not only technological but also economic and other social developments programmatically. Therefore, in line with the concept of "promising technology", this scenario had the character of an "expectation statement". It became the very successful launch of a new, far-reaching technological theme that would arouse the interest of scientists, companies, and policymakers.

Since then the actor constellations participating in the discourse have continually broadened and the concept of Industry 4.0 has rapidly gained great prominence far beyond the relevant specialist public. Indicators for this are that the topic is increasingly dominating trade fairs, encounters growing interest among companies, and has resulted in the establishment of the most diverse groups dedicated to its furtherance. Another sign of its impact is the continuous and rapidly increasing number of relevant conferences and congresses as well as an unrelenting increase in press articles in big dailies and newsmagazines down to local papers.

To follow the concept of promising technology, the constitutive condition for this growing importance of the Industry 4.0 vision is the possibility that heterogeneous actors can link their specific strategies into this expectation statement and influence its further

development in their own interest. One can discern three different interest strands that converge in the concern for Industry 4.0:

- One strand is the interest of *computer science* to have a determining influence on the production-technological and industrial development. The legitimation for this the computer scientists see in the rapidly growing importance of the "internet of things" and the possibilities for applying it usefully to industry (e.g. acatech, 2011: pp. 5).

- The second strand is the interest of *innovation-policy actors* — in Germany above all the Ministry for Research and Education — who have sought in recent decades new, politically attractive innovation ideas. Repeatedly the complaint has been voiced that in recent decades there has been a lack of innovative "lighthouse projects" precisely in industrially oriented R&D. Quite apparently the representatives of politics have now found their long dreamed-of "innovation lighthouse" — the vision of Industry 4.0.

- The third strand is the interests of *enterprises* who, after initial reservations, have increasingly become significant voices in the Industry 4.0 discourse. These are mainly the large concerns of the capital goods industry who are betting on Industry 4.0 to deliver an enormous advance in [production] innovation.

In this development phase of Industry 4.0 a shift in the existing actor constellation of the German industrial innovation system has begun. The traditional dominance of mechanical engineering and the machine industry has been markedly weakened by the very strongly IT-initiated Industry 4.0 vision. The contradictory situation arose that, though mechanical engineers for some time had been increasingly promoting IT-based solutions as manufacturing technology, their perspective could not bring them an effective innovation policy or public relations outcome. One expert made exactly this point in an interview: Industry 4.0 is impressive because the story told (by representatives of IT) has struck a nerve, and because its early advocates (engineers) could not communicate the prospects of the new digital technologies well enough. Thus, "the idea of Industry 4.0 comes from IT."

2.2 Setting a collective agenda

In the following step a process emerges that can be understood as the generation of a collectively acknowledged agenda on which is oriented the further behavior of the actors. The central mechanism is that the "expectation statement" undergoes a progressive specification

and differentiation of the partial themes, whereby forward-looking scenarios above all gain in significance (Hahn, 2013). Here the actors are assigned to specific roles and functions in an increasingly labor-dividing development context, and they receive in this way a "mandate" to develop continually further the original concept. At the same time however, they are in the social context expected to contribute (and preferably soon) convincing and useful results to the discussion (Borup et al., 2006: 291).

The German discourse on Industry 4.0 in the period 2011-13 shows a progression that in its basic characteristics strongly resembles this model. In this way an arena of discourse has emerged since 2011 characterized by a continuous broadening achieved through the participation of an increasing number of actors, increased precision of content and thematic differentiation. As observers have noted, this phase can be considered "successful agenda-building of increasing intensity and effectiveness" (Pfeiffer, 2015a). A significant feature of this phase was the politically initiated "Work Group Industry 4.0" (n.u., 2016), composed of representatives of R&D-intensive IT and technology companies, mechanical engineering and computer-science researchers, trade associations and the Confederation of German Trade Unions, as well as the Federal Ministries of Research and Economy. The work of this group was thematically divided into various sub-groups, and in the view of the participating experts this work group contributed very decisively to the substantive clarification of central concepts and thereby, to the development of a broadly accepted terminology and language. This process of agenda-setting was accompanied by a growing diversity of publicly effective activities, publications and conferences.

However, very concrete and influential *economic- and industry-policy action recommendations* were also presented by the aforementioned work group, entitled "Realization recommendations for the pioneering project Industry 4.0" in 2013 (Forschungsunion and acatech, 2013). The general goal of these recommendations was the "the creation of an Industry 4.0 community", and the rapid establishment of state-sponsored Industry 4.0 "competence centers" and demonstration plants, in order to simultaneously concretize the "vision" in terms of its performance and functional ability. Furthermore was suggested the establishment of an organization to be called "Platform Industry 4.0" to coordinate all previous, current and future Industry 4.0 activities. This platform was to be supported by the associations of the mechanical and electrical engineering and IT industries participating in previous research, and sponsored by federal ministries. It would professionalize previous efforts, systematize and above all extend the participation of companies through the industry confederations.

2.3 Structuring a stable "action context"

Inasmuch as these implementation recommendations were in large part realized, the discourse context gradually solidified into a relatively stable behavioral context with future developments considered to be forthcoming. The precondition for this was that, beyond the programmatically defined roles and division of labor that had been sketched out, a stable network structure of participating actors and a structured action context with its own logic and particular qualities should begin to emerge. This context became recognizable at the latest in 2013, on the basis of which the suggested "Platform Industry 4.0" was formally established. The industry associations in IT (BITKOM), mechanical engineering (VDMA), and the electrical industry (ZVEI) agreed in April 2013 to collaborate on the Platform; in addition, from the beginning (de facto and later officially) the unions joined the organization as well. Besides this, some large technology-intensive enterprises — from the classic capital-goods investments industry as well as the IT industry — had also been participating from the start, such as Bosch, Siemens, Festo, IBM and SAP. At the same time various thematically focussed workgroups (e.g. on IT security, the reference architecture of Industry 4.0, or innovation and research) began a continuous collaborative effort with an increasing number of experts involved in operational plants and research settings. The activities of the Platform have included above all informational and technology-transfer activities that aim to broaden, if not popularize the positive aspects of Industry 4.0, and through which successful Industry 4.0 company cases, also called "use cases" are presented to a potentially interested public (Fig. 2).

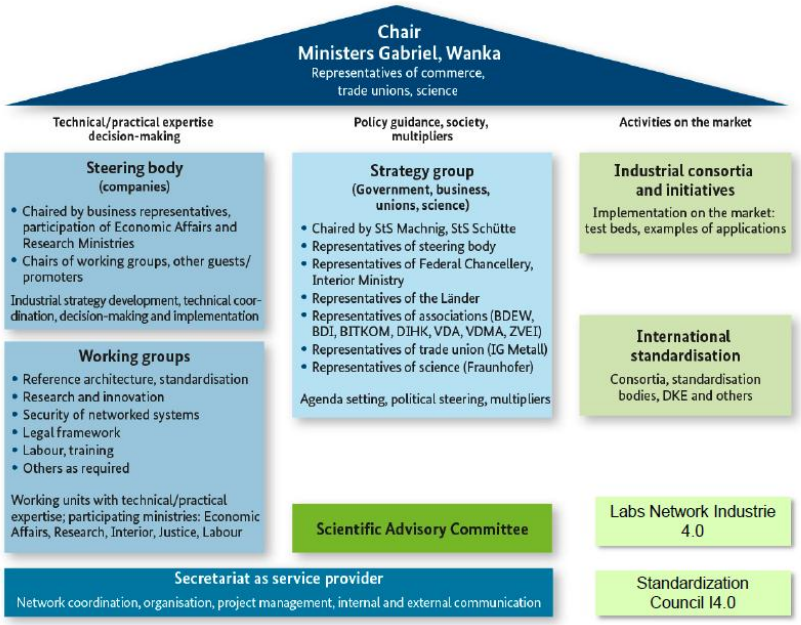

Figure 2. "Platform Industry 4.0" (source: BMWI)

The agreed goal of "Platform Industry 4.0" was "to drive the 'vision of Industry 4.0' …in the direction of industry. With that, Germany's future as manufacturing base shall be secured and extended" (BITKOM, 2015). What is more, at the same time far-reaching societal perspectives of Industry 4.0 became recognizable as the German Federal government, in a "future scenario" for 2025, decided to initiate a "broad specialist and societal discussion" over the prospects for progress that may result from Industry 4.0 for the future of industry, prosperity and employment (BMBF, 2014).

Many other individual innovation-policy measures and activities, but largely independent of the R&D activities in the context of the Platform, have been initiated and taken further on the most different levels of the discourse. One interviewed expert characterized the situation as one of a veritable "shimmering richness of Industry 4.0 activities which broaden the arena of discourse and the action context significantly by waking the interest of new actors and at the same time intensifying ongoing processes of network-building among the most diverse players.[3] To be mentioned here are, first of all, activities at the national level. The topic of Industry 4.0 has been explored at a yearly "IT-Summit" held by the federal government since 2014, where the sociopolitical importance of the "vision" has been repeatedly underscored by experts from the highest policy-making levels (e.g. the National IT-Summit, 2015). Also, from late 2014 on at the federal level, many promotional programs in favor of Industry 4.0 oriented R&D activities have been initiated by several federal ministries (e.g. BMBF, 2014). At the sub-national level of the separate federal states, and at regional levels, Industry 4.0 activities have also been launched, including specific governmental programs, conferences initiated by local authorities (e.g. Chambers of Industry and Trade) and individual companies.

Altogether the Industry 4.0 vision is becoming strongly anchored not only in the business and innovation-policy discourse, but also in the sociopolitical one. At the same time a knowledge domain is being established that has not existed up to now in this way, and to which the mentioned R&D activities have connected relatively quickly and which — above all — has been continuously advanced with a strategic purpose by leading companies in capital goods and IT. From their viewpoint, Industry 4.0 offers not only the opportunity to thoroughly modernize and rationalize their own processes, but as mentioned, also to broaden and assure the position of the German core industries on the world market. Presumably for this reason,

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[3] Part of that are naturally at the same time more or less recognizable competitive relations. Unmistakable are above all conflicts between different federal ministries over responsibility for the thematic field of digitization (Weingartner, 2016).

conspicuously many German enterprises have in recent years added their voices to the discourse.

Observable is also the coordinated action of an increasing number of heterogeneous actors, oriented on the increasingly more concrete framework, the results of which however today are still cannot be anticipated. Therefore, in line with the concept of "promising technology", coordinated development actions and technical results are not at all primarily the result of a master-plan of a controlling agency, e.g. the Platform Industry 4.0. Rather, we can speak of the emergent results of the interaction of dispersed and heterogeneous actors within an increasingly structured action space (Bender 2005: 183) established mainly by the Platform. This effect can be explained not least also by a recursively functioning coordination mechanism, which authors formulate as the "expectation requirements cycle" (van Lente and Bakker 2010): The formulated prospects and perspectives have been increasingly acknowledged by influential actors, so that the technological promise creates correspondingly more *normative behavioral pressure:* a behavioral situation in which particular reasons are required for *not taking up* the opportunity being offered (Bender, 2005: 175). This was and is particularly true among the growing number of interested companies as well as the described policy actors of various provenance. Quite apparently Industry 4.0 activities are collectively valued as proof of an orientation towards modernity and innovation.

3. Semantics of the technological promise

Overall, the Industry 4.0 discourse exhibits a strong simultaneous dynamic with the continued structuring of the technologies' development. The "technological promise" has the function of a leitmotiv for the most diverse activities of heterogeneous actors on many social and political levels. Referring to my second thesis (section 1) above, the process of generating a stable discourse arena requires a comprehensible semantic architecture of the technology promise, and discourse mechanisms that make possible through generalization a large measure of widely distributed compatibility.

This semantic architecture — to follow Alfred Kieser's instructive discourse-theoretical analysis of "modes and myths" of management (Kieser, 1996) — should be characterized by communicative generalizations, decontextualization, irrefutable currency, quantifiability, and everyday relevance. Simplifications and generalizations make easier the concise communication of the concept, creating above all connections to the experience of many actors and pre-existing discourses about necessary future industrial and societal

advancements (Dickel and Schrape, 2015: 453). What is more, with the reference to technologically solvable societal challenges, immediately the connection is made to the general political debate over societal progress, and thereby discursive compatibilities are opened for actors beyond the earlier-mentioned specialist publics. In regard to the Industry 4.0 discourse, a whole range of particularities in the semantic architecture of the "expectation statements" of Industry 4.0 can be identified.

3.1 Inevitability of the development

Starting point of the Industry 4.0 discourse is the advancement of digital technologies, seen as the driving force of the future economic and societal transformation. The opinion shared by many is that the influence of this factor, with the accelerated technology shift of recent years, is nothing less than *inevitable*. In the general view it is consistently emphasized that the high-performance technology the now ubiquitous tablets and smartphones is on the verge of being in a position to seriously penetrate and diffuse into the manufacturing world. Here particularly it is the interconnectivity of the virtual computer world with the physical world of things by the application of "cyber-physical systems (CPS)" that is the central path of this development. Production systems based on CPS, reacting to external demands, are considered to be capable in large measure of autonomously configuring, optimizing and steering themselves (Broy, 2010; Forschungsunion and acatech, 2013; Reinhart et al., 2013). This new level of automation is based on the continuous self-optimization of intelligent, decentralized system components and their autonomous adjustability to dynamically changing external conditions, for example, of markets, production and delivery chains, or to unforeseen environmental conditions that may emerge in real time (acatech, 2011: 23).

3.2 Overwhelming economic prospects

The interest and expectations of a multitude of actors can be awakened by the foreseeable leap in *economic progress* that the new technological potentials will enable. The general goal of the Industry 4.0 concept is to manage the growing need for an automation-technological flexibility of outlets, increasing individualization of products, shortening product life-cycles, as well as the rising complexity of processes and products (e.g. Forschungsunion and acatech, 2013).

If one summarizes the various positions, commentaries and above all statements from speeches by company representatives, research scientists and most importantly, politicians,

very far-reaching economic expectations become recognizable. For example, a widely received study assumes an economic growth for Germany enabled by Industry 4.0 of 78 billion Euro up to 2025, whereby for single sectors such as machine and plant construction, growth rates of up to 30 percent are predicted (Bauer et al., 2014). A similar example is a study by the enterprise consultancy PWC. It says that, within five years after the introduction of Industry 4.0 systems, productivity increases of ca. 18%, and sales growth per year of 2-3% can be expected, with projections of yearly sales growth of 30 billion Euros for the entire industrial sector (PWC, 2014). Furthermore it suggested that by 2014 just under one-fifth of industrial enterprises would have digitized key processes, and that by 2019 this will make up 85% of all companies. The message of such numbers is unequivocal: whoever joins this transformation endeavor will be successful practically by default and in a position to achieve enormous profit gains.

In addition, in the German context worry is unanimously expressed about the threat of competition from the large international digital concerns and the development efforts of other countries that have already pushed further the frontiers of digitization. The danger is seen that large players such as Google with their big-data capabilities sooner or later will acquire a market-controlling position also in the industrial sector, and that German industry operations will be degraded to the role of suppliers. Furthermore the efforts of above all of China and the US are unanimously regarded with alarm for their development of industrially applicable digital technologies. The view that the ongoing technology development is inevitable makes all the more pressing the pessimistic remark that Germany has actually already "slept through" some fundamental steps in the digitizing process, and therefore now needs to make that much greater efforts (e.g. Cole, 2015).

3.3 Sociopolitical legitimation

The general public interest in Industry 4.0 far broader than only the specialists' interest is also being awakened by the possibility that it may offer solutions to societal challenges. Thus for example the much greater resource efficiency of industrial production through Industry 4.0 is mentioned as a way to avoid dealing with growing resource shortages and ecological problems. Moreover, it is constantly underscored that Industry 4.0 will almost necessarily lead to demanding but secure and well-paid high-quality jobs, and to significant improvements in the work-life balance. With Industry 4.0, thus the further argument, is offered at the same time solutions to the lack of specialists in the labor force and, in the longer term, also to the demographic problem (e.g. Kagermann, 2014). As the central precondition for this is seen the

potential of digital technologies to make educational and occupational training processes more effective and above all also faster and more target-group specific (e.g. Barner et al., 2015).

Sociopolitically however, the "Industry 4.0 Vision" exhibits a surprising double face. On the one hand it puts traditional industrial production at the focus of the vision. This is the economic sector which some years ago was represented in the public debate as the — increasingly negligible — "old economy", in contrast to the rising "new economy" of the "knowledge society". But on the other hand it is postulated that the new digital technologies will give this traditional sector a developmental impetus with a rich potential of future solutions and possibilities. In this sense a fusion of the forward-looking perspectives of the "new economy" with those of the industrial "old economy" is suggested. This is accompanied by high public esteem for the German industrial sector due to the successful German counter-measures in the management of the financial crisis after 2008.

3.4 Generalization from single cases

In addition, the need to introduce the new technologies preferably comprehensively and rapidly is reinforced by the continuous and intensive attention to companies that have already achieved evident success in Industry 4.0. German companies such as Siemens in Amberg, or Wittenstein AG, or the machine-tool constructor Trumpf are presented as technological leaders who have been economically particularly successful and therefore can serve as orientational models for the strategies of other enterprises. These apparently successful company cases move players therefore towards an intensive preoccupation with the new technological possibilities, often less in direct relation to performance gains than for the purpose of legitimation. If someone wants to avoid future risks and not be considered old-fashioned it will be difficult to justify not following the trend (section 2.3).[4]

Of course in the specialist discourse no one denies that a rapid digitization of companies and the realization of Industry 4.0, from vision to application will not be easy — if not beset with great difficulties. Fairly long periods are assumed necessary for the complete diffusion of digital technologies — an interim of up to 25 years is spoken of. At the same time the disruptive character of the innovation is often mentioned which will entail a long-term and risky transformation of techno-organizational company structures, in particular the

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[4] Referring to sociological New Institutionalism, one can interpret this mode of behavior as an equalization of enterprise structures through mimetic isomorphic mechanisms.

introduction new business models (Forschungsunion and acatech, 2013). Therefore, successfully meeting these challenges will be proof of a successful management as well as forward-looking innovation and social policy. Because, with ultimately high profits and societal modernization beckoning, great expectations in terms of the economic and social benefits are being aroused among potentially interested actors. The stakes are as high as the undertaking difficult.

3.5 Favorable timing

The expectation that the digital technologies will offer potentially sustainable solutions to social and economic challenges and thereby a desirable societal transformation, seems only convincing if the timing is right. As Kieser formulates it, the vision must strike the "nerve of the times" (Kieser, 1996: 26), and as already suggested, this applies to the Industry 4.0 discourse in several ways. For one thing, it is to a great degree compatible with the rapidly growing general focus in society on digital technologies and Internet, and with the dominant conviction that this is no less than a societal mega-trend. For another thing, it is very similar to the "dot.com" phase of the late 1990s, marked by the exceptional success and growing influence of the emerging big internet concerns. These should be not only emulated, but also, the already mentioned fear of a growing dependence of German industry on e.g. Google et al. should be counteracted by a push towards more rapid digitization. Similar to many management modes and concepts of the past decades, the "vision Industry 4.0" distinguishes itself through a "shrewd mixture of simplicity and ambiguity": its superiority appears simple, clear and convincing, and is hard to argue against (ibid.: 24).

This general attractiveness of the concept is supported by its name. As already mentioned (section 2.1), the term "Industry 4.0" is a masterly example of PR without equal. As shown, it has defined for several years the industry and sociopolitical debate not only in Germany, but increasingly also in other important industrialized countries such as China.[5] For a rapidly increasing number of scientific, industrial and political actors a fully new perspective on industrial development has opened, with the impetus towards a fully new modernization, indeed suggesting nothing less than a "fourth Industrial Revolution" of industrial development. Those enterprises already active in this endeavor undeniably enjoy the attribute of being in a forward-looking, leading role, and innovation policy in the general sociopolitical

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5 Of course this vision is not exclusively a German idea: for several years parallel discourses have been underway, often labelled internationally as "advanced manufactuing", above all in the U.S.

debate has now found its communicable "lighthouse" as proof of its orientation to the future. Calling for the "fourth Industrial Revolution" as a prospect worth striving for contrasts to, instead, a narrow vision of the future, one of risk- and retrenchment-mindedness. A very broad impact will also be thereby assured if the discourse can abstract broadly from concrete technologies and, with Industry 4.0 as described, a large number of very different digital technologies are addressed. Therefore Industry 4.0 is of high interest for companies of diverse structural characteristics and technical requirements and for other involved actors. As already stated (section 2.3), the main feature of this discourse is an information-determined narrative with promises that reach far into the future. Not accidentally this is also stressed in the 2015 memorandum of the "Platform Industry 4.0", where it is underscored that an "attractive narrative" and "collaboratively supported statements" by all participating actors is the precondition for the media and public's understanding of the significance of and the opportunities offered by the digital transformation in Germany (BMWI, 2015: 5).

4. Ambivalence of the technological promise

In the period starting from ca. 2011 a progressively more precise, coordinated and structured Industry 4.0 discourse and "vision" can be identified. Since then, many state-funded R&D-projects with different technological perspectives have been launched, but only a few actually operating Industry 4.0 plants have been realized. Also, de facto most company-specific technological plans and the economic prognoses and profits remain vague and only rarely calculable on the basis of concrete techniques and projects. To date it has not been recognizable that Industry 4.0 has established itself as a strongly coherent sociotechnical field with a concrete, available new technology. A best, Industry 4.0 is only being defined by the basic dimensions of new IT technologies like networking, cyber-physical systems or big data. Rather, as outlined above, Industry 4.0 has to be regarded as a process of "productive communication", which reveals technological development perspectives and at the same even popularizes the possibilities for economic and societal advancement pushed by the diffusion of digital technologies (Dickel and Schrape, 2015: pp. 455). A high level of sociopolitical attention is thereby produced, a horizon of possible futures mapped and many actors provided with decisional orientations about future strategies; in this way technological, economic and societal complexity is reduced. This is the case especially for companies that want to develop new forms of technology applications and new business models, as well as for research, which recognizes potential new fields and wants to open possibilities for funding.

However, the promising technology — referring to the third thesis (section 1) — exhibits a strikingly ambivalent character. On the one hand it has attained with its far-reaching generalizations and decontextualization a practically techno-utopian character. But on the other hand also increasingly skeptical voices and critical positions are gaining attention by stressing the social risks and potentially negative societal consequences. This ambivalence can be shown in the following aspects.

4.1 Industry 4.0 as "techno-utopia"

As made clear by the semantics of the Industry 4.0 discourse, with this vision are above all also promised possible solutions to urgent sociopolitical challenges. The discourse and the vision of Industry 4.0 are not limited to technological perspectives: at the same time explicit expectations for the future of society are formulated (e.g. BMWI, 2015). The Industry 4.0 discourse is in many ways an unbroken continuation of optimistic, technologically-based "growth" and "progress" narratives (Pfeiffer, 2015a).

This nexus of technological potentials and positively connoted societal change shows that Industry 4.0 is far more than just a technological "expectation statement". Rather, the "vision Industry 4.0" is often taken to imply a societal perspective extending far into the future. It is therefore not exaggerated to say that the Industry 4.0 discourse shows the broad traits of an expressly techno-optimistic, if not a fully techno-utopian character.

The concept of techno-utopia as a societal discourse dates back to the classical social utopias of the 19th century, in which social critique and societal counter-culture projects occurred together with the technological upheavals of the time. Techno-utopia as "form of the social construction of the future" is experiencing a new flourishing, and in some ways is comparable to the era of the 1950s and 60s with its focus on the emerging possibilities of space flight and the potentialities of atomic energy (Dickel and Schrape, 2015: 442). This has been observable in scientific and political discourse above all with the rise of the "knowledge-society", resp. the "information-society". Formulated more generally, the rapid development of "high-tech" quite apparently offers, for many of its proponents, plausible and probable solutions to urgent social problems (Segal, 2005: 166).

The "technology promise" of Industry 4.0 can also be located within the tradition of this perspective. As sketched above, it is assumed that the introduction of digital technology will bring the opportunity of managing long-term foreseeable and future societal challenges

and thereby of entering a new phase of economic growth and social advancement. Blurbs such as "Hundreds of thousands of new jobs created", "Never was training so accessible, and never so much fun", or "Networks are making experts faster and smarter, helping us throughout our lives" illustrate the social-utopian thinking connected with Industry 4.0 (BMWI, 2016). Often with very generalized, positive connotations, an attractive and sustainable transformation of the work environment is predicted. With abundant references to Google and Silicon Valley, forms of digitized, networked, high-flexibility, autonomous, self-determined and creative "knowledge work" is generalized into the "normal" sort of work that will predominate in the future (Weinberg, 2016). Representative of the opinions of a fair number of authors may be that of Henning Kagermann, one of the leading originators of the "Industry 4.0 Vision" in Germany, who believes employees of the future will work less as "machine operators", and more "in the role of transmitters of experience, deciders and coordinators so that the amount of work content will increase for the single worker" (Kagermann, 2014: 608).

In this view progressive digitization will also bring potential for the democratization of society, in a hitherto unknown kind of social development. This is foreseen for one thing in regard to hoped-for changes in business, as well as, for another, in regard to society as an entirety. Unknown potentialities have been emerging for involving companies' personnel systematically in internal decision-making processes, for increasing very significantly digitally supported participation and voice of staff — the term here is "liquid democracy" (e.g. Sattelberger et al., 2015). In regard to societal trends, also the emergence of new levels of social interaction, resp. for taking social action through social media are predicted. Thus, there will result not only a "real jump in productive power", but also the effect that "people will be able in this new space to communicate, work and learn together, develop ideas, share knowledge and experience, or simply 'hang out' together." (Boes et al., 2015: 62). Moreover, digital technologies are being regarded as the determining factor that the crisis-ridden capitalism will be overcome. Sooner or later we will witness the emergence of new post-capitalist society with more social equality and justice, participation and democracy (Mason, 2015).

Without question, with this vision of the digital future once again a "roseate picture of a post-industrial wonderland" (Webster and Robins, 1986: 20) is being drawn. Or, in another formulation: "Information technology, we are told, holds the promise of wealth, global

democracy and political participation" (Jeffcote, 2003: 8).[6] Somewhat exaggeratedly one can therefore also speak of the "digital revolution as new religion" (von Becker, 2016).

4.2 Contrasting voices: skepticism, critique and fears

The Industry 4.0 discourse is however also increasingly subject to skepticism over the feasibility of its vision and fear of negative social consequences. The realizability of Industry 4.0 itself is questioned and the expected economic benefits seen as overblown. With pointed formulations such as "Industry 4.0 — the great self-deception", reference is made to the even now largely incalculable expense of the realization of Industry 4.0, above all for SMEs (Maier and Student, 2015). Critics assume that particularly small and medium-sized companies (SMEs), because short on resources, in the long term will be overstretched by an attempted introduction of digital technologies. Available budgets for funding digital technologies in the majority of SMEs are considered "perceptibly low", which also in the coming years will probably change but little (Agiplan et al., 2015: 133). Not by chance therefore in interviews at even middle-sized companies about the importance of digitization, a good one-third said that the topic was for them at present not at all relevant; among SMEs this was as much as 70% (Maier and Student, 2015).

Similarly critical were experts interviewed in regard to the degree of innovation inherent in the Industry 4.0 concept. Some observers have asked whether the current debate it isn't just a case of the proverbial "old wine in new bottles" (Jasperneite, 2012). This question was justified by the perception that Industry 4.0 can only with some difficulty be distinguished from its predecessor concepts — mainly, IT-supported production technologies — and therefore one can hardly speak of a technology jump to a "fourth Industrial Revolution".

Moreover, Industry 4.0 can be traced back to the production concept of "database networks" from the 1980s, discussed in recent decades under the well-known buzzword term "Computer Integrated Manufacturing" (CIM) that was in the 1980s and 90s at least partially realized (e.g. Harrington, 1973). Technologically considered, some similarities between the CIM-concept and Industry 4.0 are in fact unmistakable. The idea — an information-technical integration of production and logistics over the entire value chain and the connection of the

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6 From a still more general viewpoint, similar perspectives, labelled for example "digital enlightenment", have been generally associated with the Internet (e.g. Urchs and Cole, 2013).

virtual with the real production level — was already anticipated by CIM (Menez et al., 2016). Even then a similar economic goal was formulated as for Industry 4.0 today: to flexibly shape value-creation processes, to run specified processes profitably and be able to react flexibly to disturbances (Brödner, 2015: 238). Although CIM, because of technological barriers at that time, was scarcely realized, now it is assumed that with the newer technology these earlier ideas are today viable. Not surprising is therefore that none other than the earlier German "CIM-Pope", A.W. Scheer, has stressed the continuity of technological development (Scheer, 2013). For the same reasons, other experts consider the innovativeness of that which is currently understood as "Industry 4.0" as somewhat limited. They think that not only are the concepts not actually new, but up to now they cannot recognize any real, advanced progress towards the industrial use of new intelligent systems. Therefore it has been ascertained that "…the 'Fourth Industrial Revolution' is revealed to be mainly a revolution of words …, though in the presence of an enormously increased performance of digital technology which will make possible applications that were earlier beyond reach" (Brödner, 2015: 239). If one adheres to these arguments, Industry 4.0 is less the driving agency of a new industrial revolution, than the expression of a path-dependent advancement of earlier technological concepts.

Besides these technologically justified objections, in the current discourse over Industry 4.0 are also increasingly gaining significance questions about possible negative risks for work and work qualifications. An indication of the relevance of this issue is a discussion process called "Work 4.0" at the Federal Labor Ministry, in the course of which the conditions for desirable new forms of "good" digital work were to be elaborated (BMAS, 2015). In this context risks such as "dequalification", a distinctly heightened potential for worker surveillance, forced flexibilization, the potential for increased stress, and above all the danger of job losses are mentioned (e.g. IG Metall, 2013; Kuhlmann and Schumann, 2014). Fully contrasting with the positive economic prognoses mentioned earlier, the fear of extensive job losses are the object of the most intensive public debate and an increasing number of studies. An important point of reference here is the broadly received study by Frey and Osborne (2013), in which the central statement is that prospectively, around one-half of all occupations (47%) on the US labor market fall into the high-risk category, i.e. they risk becoming fully automated in the future. The study forms the background for further, mostly critical analyses of digitization, and discussion contributions on the question of its transferability to other countries and regions, which in part posit considerable substitution effects. Therefore the theme of job loss has assumed in the public debate on Industry 4.0 a steadily increasing significance and contradicts quite evidently the techno-optimists' perspective on it.

And finally in this context, decidedly sociocritical positions should also be addressed. These refer however less to the Industry 4.0 discourse than to generally questionable and undesirable societal consequences of digitization. Here, above all, American authors play a prominent role (e.g. Morozov, 2013; Zuboff, 2014). Several strands of argumentation can be distinguished:

First, authors deny the positive economic and societal prospects of digitization. The fundamental argument is that digitization is not a realm without boundaries and that capital scarcity sets limits for capitalistic development (Betancourt, 2015). It is also highlighted, that there will be a growing gap between productivity and market demand; while productivity increases massively, demand stagnates. Therefore, authors speak of "false promises" concerning totally exaggerated growth prospects of digital capitalism (Staab, 2016).

Second, it is feared that internet networking, big data and platform technologies could lead not only to a still more massive increase in economic power of the well-known internet corporations, but also could be used for politically fully uncontrollable surveillance activity. With that would probably be threatened not only the freedom of the individual, but ultimately that of whole societies (e.g. Hofstetter, 2014; Zuboff, 2014; Roßnagel and Richter, 2016). Worse still is the threat of sheer "technological totalitarianism" (Schirrmacher, 2015) or of a societal structure characterized as "surveillance capitalism" (Zuboff, 2016).

Third, critical arguments address the growing autonomy of technological systems. The fear is that intelligent robotic systems, such as self-driving cars or "smart robots" in manufacturing processes, will force their way into areas that until now have been only under human control and responsibility, and then might fully escape that control. The danger is perceived that "…the rich traditions of moral thought that guide human relationships have no equivalent when it comes to robot-human-interaction…We face a future in which robots will test the boundaries of our ethical and legal frameworks with increasing audacity." (Nourbakhsh, 2015: pp. 23). Addressed here are far-reaching, but until now hardly apprehended ethical problems, such as the question of a moral grounding and justification of the decisions to be taken by machines. The question of who ultimately will bear responsibility for the "machines decisions" is another critical point. In diametrical contrast to the techno-utopian arguments critics do not exclude that with digitization we may be risking a total societal dystopia in the future (e.g. Butollo and Engel, 2015; Nourbakhsh, 2015).

5. Concluding perspective

In closing, the question is pertinent as to how the Industry 4.0 discourse will further develop. It has given cause without doubt to important considerations and has a central behavior-coordinating function. As the ambivalence of the promising technology shows, the often ascribed clearcut consequences and advantages, and the positive perspectives on its further advancement can hardly be presumed to follow from it. Innovation research speaks here of the "hype cycle" of technological innovations, which sooner or later, from the heights of exaggerated expectations and enthusiasm, will finish in a deep pit of disappointment after many of the expectations show themselves to be unfulfillable (e.g. Fenn and Raskino, 2008).

Should it be feared that the promising technology of Industry 4.0 and with it the discourse arena will suffer this destiny? In other words, may Industry 4.0 befall that development which Alfred Kieser makes responsible for the demise of modes in management. In particular, he points to the factor of time: modes wear out and often lose their effect with time as symbols of progress. "The arena is full because meanwhile almost everyone has jumped on the bandwagon, and now everybody can talk—and wants to. Too many companies can adorn themselves with it. The concept that gave a particular mode its name becomes, because of the innumerable attempts at differentiation, so variously denoted that the word becomes practically meaningless." And then the situation can emerge that, for "…the creation of an effective rhetoric in companies, the concept is too worn out." (Kieser, 1996: 33).

An essential reason for this phenomenon is, that in the course of further attempted realizations of the concept, the spectacular expectations are simply not achieved, while unexpected and risky side-effects appear. The skepticism of many companies has been mentioned once already. In case far-reaching cases of data manipulation, espionage or data theft in companies should become known to the greater public, probably a skeptical attitude towards Industry 4.0 would receive thereby a quite considerable impetus. Moreover, much speaks for the eventuality that the expected positive economic effects will turn out to be long in coming. A great number of research results demonstrate that not in every case is there a positive relation between an investment in information and communication technologies and productive increases; prognoses of cost savings are often completely exaggerated and bear no resemblance to economic reality. Besides, foreseeably high initial investment and implementation costs, at least for the coming years, will limit the prospective profitability (Agiplan, 2015: 133).

Therefore, the discourse space of Industry 4.0 and the actor constellation that supports it may begin to lose stability. One cause of this may be a growing number of doubting and frustrated companies. Another reason is that the effectivity of the described diverse and multi-dimensional economic and innovation-policy influencing measures is not at all assured, so that here also skepticism and criticism can grow. And finally there is the question whether politically the topic of Industry 4.0, in view of the many other sociopolitical challenges today, will be considered by the leading political actors to be a mobilizing issue in the coming years. Above all, the above-sketched general criticism of digitization and its potential dangers may gain ever greater sociopolitical influence. Politics should increase its attention to these objections and take increased regulative action against internet-based concentrations of power, as well as improve data protection, instead of mainly only seeking to force ahead the digitization process at all costs.

This could mean that in the longer term the technology promise of Industry 4.0 will have to pass through a long dark valley of disappointments and lagging enthusiasm before a new phase can begin in which further advancements in the concept will doubtless be attempted. It can anticipated that such a coming developmental phase will be one of more limited and realistic economic and social expectations. Inevitably by that time the promising technology of Industry 4.0 will probably have lost at least some of its glamour.

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