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DIGITALIZATION OF INDUSTRIAL JOBS IN GERMANY

Prospects for human-oriented work design

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Friedrich-Ebert-Stiftung

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Hartmut Hirsch-Kreinsen contributed this chapter for FES.

GERMANY

84,050

GDP per person employed (constant 1990 PPP $)

87.6

Internet users (per 100 people)

117

Mobile cellular subscriptions (per 100 people)

2.87

Research and development expenditure (% of GDP)

17

High-technology exports (% of manufactured exports)

CHAPTER 03

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Introduction

The diffusion of digital technologies in manufacturing will have far-reaching consequences for jobs and skills. This is especially true for the German economy, where manufacturing accounts for roughly 22 percent of the country's Gross Domestic Product (GDP).[1] Most experts believe that the increased use of technology will alter production processes with potentially disruptive social and economic consequences. The world is on the cusp of a new digital era referred to as the "second machine age,"[2] the "third industrial revolution"[3] or, in Germany, the "fourth industrial revolution" or "Industry 4.0."[4]

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The diffusion of Industry 4.0 systems and increased digitalization is changing the world of work. These changes will become commonplace in the future, but predicting the consequences of digitalization for jobs and skills is a much harder task. Experts have varying views on the consequences of the growing diffusion of technology. On the one hand, there is an optimistic perspective that emphasizes positive consequences for labor, skills and income. On the other hand, digitalization is expected to create some very thorny challenges for the future of work, such as the "de-skilling" of work and job losses.

This chapter examines expert arguments and existing literature on the consequences of the greater use of digital technologies from a labor market perspective. The author focuses mainly on examining potential changes in industrial work and explicating the tenets of the intensive debates taking place in Germany on Industry 4.0. More specifically, this chapter addresses the following questions: How has the nature of tasks required for industrial work evolved over the last several years? How is this evolution transforming work?

Second, the author proposes a response to technological change rooted in the principles of job design to guide the future of industrial work, while maintaining a focus on skills. Focused on these issues, this chapter will not address other debates around the digitalization of industrial work, such as wage polarization and increasing income inequality. The paper is mainly in reference to the German context, but lessons can be extrapolated for other countries as well.

How has the nature of tasks required in industrial work evolved during the last several years? How is this evolution transforming work?

This chapter draws on existing research on industrial work and labor that deals with the diffusion of digital technologies in industrial sectors. The analysis also uses the preliminary results of a series of semi-structured interviews carried out by the author with policymakers, representatives of industrial associations, unions and management representatives of manufacturing companies in Germany.[5,6] Despite the global debate around the impact of technological advancement on labor markets, the body of research on the transformation of industrial work is surprisingly thin.

Opposing perspectives on the evolution of industrial work

Many studies suggest that digital technologies will change the nature of work in almost all sectors, including manufacturing. From the activities on the shop floor to related areas such as planning, control systems and product development, all aspects will undergo significant transformation. Consequently, the demands on leadership and management will also change. Although experts predict thorough reorganization of work within companies and in the relationships between companies and their value chains, they do not agree about how industrial work will change and what those changes will mean in terms of job opportunities and skill requirements.

Pessimistic perspective

One line of argument can be characterized as pessimistic about how the future development of industrial work will affect workers. According to this perspective, the rapid development and dissemination of digital technologies, and an increasingly growing gap between the new demands of technology and the difficulties in skilling and re-skilling workers will mean fewer opportunities for employees.

This argument contends that the demand for many tasks and qualifications will decline as digitalization advances, reducing the number of available jobs.[7] Frey and Osborne support this view in a study of the U.S. labor market. They show that there is a significant potential for job losses to go hand-in-hand with the use of digital technologies, and conclude that approximately 47 percent of all activities in the American labor market over the next one or two decades could be threatened by automation.[8] Other authors present similar findings for the European and German labor markets. Bowles comes to the conclusion that in the long term more than half of all jobs in Germany are threatened by automation.[9] Another study predicts that for the German economy as a whole, 59 percent, or more than 18 million jobs, could potentially be lost as a result of automation.[10]

Experts with a pessimistic view of technology argue that increasing adoption of technology will erode jobs requiring medium-level skills, and will instead favor jobs demanding higher qualifications or jobs that cannot be routinized easily. This 'skill-biased technical change,' as it is frequently referred to, will exacerbate labor market inequalities.

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Historically, labor-intensive manufacturing work such as automotive installation and system monitoring, as well as many routine administrative and service activities that require medium skill levels, can be replaced by automation more easily.[i,11] In the pessimistic view, automation of these jobs will accelerate, but two types of jobs will persist and continue to be in high demand:

[i] *David H. Autor argues that the analysis should primarily focus on tasks and secondly on the skills. Following this "task approach," a task is a unit of work activity that produces output whereas a skill is a worker's stock of capabilities for performing various tasks.*

(1) complex activities in high-wage areas such as management, consulting or financial services, and (2) low-wage jobs in social work and sectors like healthcare, plus simple and manual tasks that – due to particular material characteristics – cannot be routinized on a factory floor. Goos and Manning characterize this trend as the emergence of "lousy and lovely jobs,"[12] and one of its primary consequences is rising inequality.

Similar trends toward a differentiated structure of activities are discussed in research on industrial work in the context of intelligent network logistics systems – automated systems for managing supply and distribution that rely on digital technologies, such as the self-controlling storage systems used by manufacturing companies. A clear job polarization is already taking place: On the one hand, sophisticated, more high-skilled occupations such as managers and supervisors have been created to run the new systems. On the other hand, low-value added tasks and simple activities like packaging and assembling were retained, since the cost of automating these tasks is still higher than the cost of paying a low-skilled workforce to execute them. Companies often avoid fully automated systems due to high technological complexity and high cost, but the tasks they automate are those that would have been performed by middle-skilled workers.

Optimistic perspective

Another strand of research predicts more positive effects of digitalization: job creation, increased skill requirements, and a general revaluation of jobs and skills, together constituting a "new, more humane turn."[13] These optimistic studies suggest that the efficiency gains, new products, new markets and new employment opportunities in the longer term will compensate for the negative employment effects of technological change in the short-term.[ii,14] In Germany's Industry 4.0 debate, experts predict

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[ii] *Evangelista et al. (2014) see little clear impact on employment, on the basis of a detailed literature review in anticipation of the adoption of digital technologies. In particular, they emphasize that it is particularly difficult to attribute causal effects on employment to digital technology.*

high productivity gains and higher economic growth rates[15] as well as consistently better jobs as a result of technology adoption.

The vast majority of manufacturers expect the share of the workforce employed in industrial production to remain relatively stable and significant over the next few years and do not expect large negative employment effects.[16] The same result is found in a study by the Boston Consulting Group, which predicts a 6 percent increase in employment in German manufacturing over the next 10 years, or about 390,000 jobs between 2015 and 2025.[17]

With respect to skills, experts predict that digitalization of work will bring a growing appreciation or an "upgrading" of worker qualifications. First, this is considered to be the result of increasing automation of jobs such as machine monitoring or simple and highly routinized assembly work. Second, upgrading will affect all employee groups. In this perspective, digitalization of work is a process of computerization, which makes a wide variety of information about ongoing processes increasingly available. The complexity and possible applications of technology result in fundamentally new and presently unknown requirements for all job-related activities. Current information technology applications in the context of Industry 4.0 reflect how technology adoption can prompt greater efforts to upgrade the skills of workers. For example, skilled machine operators are now able make decisions about work flow sequences on the basis of an optimized control and information system.

New technology provides data and evaluation capabilities that allow for a much higher degree of transparency in production processes. The optimistic perspective emphasizes that a general upgrading of qualifications in the future will not only be possible but is inevitable. One leading expert in Germany's Industry 4.0 debates, Henning Kagermann, expects that people in the future will be employed less as "machine operators" but rather as "mediators of experience, as decision-makers and coordinators ...[that is] the variety of job content for the individual employee will increase".[18]

Research findings also show that the model of work in German manufacturing industries is evolving into one characterized by a very limited division of labor and high flexibility. This model is referred to as a "holistic work organization," or metaphorically, "swarm organization" – a loose network of qualified and equally entitled employees. Simple and low-skilled jobs are being replaced by automated processes.

The central feature of this organizational model – which research shows is already present in the

German automotive industry – is the absence of defined tasks for individual employees. Rather, the "work collective" functions in a highly flexible, self-organized, and situationally determined way, adapting its behavior to the problems that need to be solved around the technological system. The German automotive industry was previously characterized by very low-skilled and repetitive assembly jobs. Today, "smart" robots substitute many of the low-skilled, highly routine assembly tasks. The remaining jobs focus on tasks like maintenance, quality assurance, and personal planning. They are pursued in a highly informal and flexible way. But in order for this new work model to be successful, workers need to be appropriately trained and continually upgrade their knowledge on the job.

Adopting the technology and establishing the corresponding work environment is not easy.

Requirements for work design

To summarize, there are opposing perspectives on how the digitalization of work will affect workers of different skill levels and the nature of jobs. Of course, the pessimistic perspective does present a possible scenario. However, labor research provides generally plausible reasons to be optimistic, particularly with regard to an upgrading of skills. Cooperative work processes, especially those characterized by high levels of workplace autonomy, can help skilled workers effectively harness digitalized systems to their advantage.[19]

Yet adopting the technology and establishing the corresponding work environment is not easy. Complex production systems are very susceptible to interference, and may have non-transparent and unpredictable effects.[20] Therefore, workers will require a high degree of flexibility and problem-solving skills going forward. Finally, the lifecycle of complex systems can always involve new system states that are difficult to control, such as unexpected start-up problems as well as unexpected disturbances in normal operation. Those can best be overcome in the context of open and informally designed forms of work. The model that the German automotive industry has begun to adopt may be the most effective in ensuring a positive pathway for industrial work.

Work design

The way that industrial work evolves in response to technological advancements will depend in part on how policies and stakeholders shape work design. Work design, or job design, refers to the way labor is deployed in a particular company or institution – the way jobs are executed and the kinds of tasks and interactions they involve. It affects the skill variety and autonomy of the job in question.

Multiple economic and social factors and labor market policies have a bearing on work design and the complex interaction between technology and jobs. These factors will ultimately determine how new technology is adopted and how it shapes the future of work.

One response to the digital transformation is to encourage the implementation of a skill-oriented work design model. This requires a proactive vision from company managers, worker councils and unions. It also requires labor policies that are rooted in an understanding of the complex relationship between the proliferation of digital technologies and their social consequences. The following section will outline the conceptual and normative propositions of this approach. It will focus first on its starting point, the concept of a "socio-technical system," and second on the system's interfaces as the main areas of job design.

Socio-technical approach

An analytical starting point for a skill-oriented design concept is the "socio-technical system" – an approach to work design that emphasizes the interactions and interdependences between technology, humans and the organization as a whole. Although research has not always been consistent in its definitions, a socio-technical system can be understood as a production unit consisting of interdependent technology, organization and personnel subsystems.[21] In this concept, the issue is not one of "either technology or human action," but one of a holistic design, which not only produces a good or a service but also attempts to ensure job satisfaction for the worker. This approach takes into account the functional relationships and interfaces between workers, technology and the organization as a whole. Work design is oriented around humans and their potential.

An analytical starting point for a skill-oriented design concept is the "socio-technical system" – an approach to work design that emphasizes the interactions and interdependences between technology, humans and the organization as a whole.

Based on original research on skill-oriented work design, the author has identified the following basic challenges in incorporating the socio-technical approach in companies utilizing digital technologies.[22,23]

The relationship between the worker and technology

The first relevant interface is the relationship between technology and human labor and the "distribution of behavioral responsibility." How functions are delineated between the worker and the machine is one of the fundamental challenges for systems that rely on digital technologies. In skill-oriented work design, the objective is an interface design in which the human worker obtains or maintains control over production processes and is supported by intelligent assistance systems. The resulting work situation can be characterized by an extended range of tasks supported by "social media" functions, such as the use of tablet computers and data glasses that are web-connected for communicative and supportive functions.

The relationship between the worker and the organization

The interface between the organizational structure and the worker is the second important area of work design. The way an organization or company is structured ultimately determines a worker's job profile and the associated qualifications that are required. Here, the key challenge lies in determining how labor-intensive a task should be as well as what learning and training opportunities the organization provides a worker. There are a lot of possibilities for an organization design that is aimed at a positive revaluation of all jobs and skills. For example, various forms of group work, including staff rotation in the field of assembly operations, reflect a human-oriented approach to work design. Such work situations are characterized by a high degree of operational freedom and include various possibilities for "learning-on-the-job."

The relationship between technology and the organization

At the interface between technology and organization, challenges emerge for the design of work in several ways. First, the level of automation determines which tasks should be performed by machines and which should be performed by workers. Second, since digital technologies enable the separation of a worker's task and a machine's task in terms of time and space, there emerges a wide scope for alternative forms of organization. Third, with networked systems, the organizational design not only includes the horizontal dimension of the shop floor but also the vertical or hierarchical dimension of the work organization and supply chains. New forms of

communication enable the horizontal, vertical and hierarchical integration of organizations.

These functions permanently connect the areas of planning, managing and engineering as well as executive and management functions. Here in particular, the new conditions for manufacturing on the basis of autonomous, self-regulating systems must be considered. In terms of a human-oriented organizational design, this could indicate a turn toward far-reaching decentralization and the delayering of hierarchies.

A framework for the future of work

Building on this conceptual framework, a preliminary design for work in the digital era is taking shape. The socio-technical approach and the holistic design of the industrial production process are critical for skill-oriented patterns of work organization to emerge.

Basic criteria for the development of a human-oriented design of "Industry 4.0" work should be:

- The workers on the factory floor should have far-reaching monitoring and regulation capabilities over the technological systems, in order to be able to solve directly and efficiently unexpected system disturbances.
- Intelligent assistance systems should be adopted. These should be flexible enough to adapt to diverse skill levels and support on-the-job training.
- The highly decentralized structure of digital systems should be used to reduce hierarchies and implement new forms of self-organization and a far-reaching autonomy of workers on the factory floor.
- Management styles must move toward participative management – an approach that encourages the involvement of employees at all levels of an organization in analyzing problems, developing strategies, and implementing solutions. This is a central prerequisite to bring about increased autonomy on the factory floor.

Most companies still focus on addressing the technological problems that arise with the adoption of more automated systems.

According to the author's research findings, in Germany only a few industrial firms are pursuing such a skill-oriented design strategy. Most companies still focus on addressing technological problems that arise with the adoption of more automated systems. In order to promote the skill-based implementation of digital production systems, institutional and political measures are required as well.

Policy frameworks can enable and incentivize the adoption of human- and skill-oriented work design in the context of digital transformation. The following policy recommendations represent a step in this direction:

1. Germany's government should increase public funding for research and development on new skill-oriented patters of work organization that take into account the principles outlined in this chapter. The research could inform capacity-building programs for businesses that want to implement skill-oriented work design but lack an understanding of how to do so.
2. The promotion of advanced vocational training activities can increase the availability of the types of skills and qualifications required to implement skill-oriented work design. Adoption of participative management styles and human-oriented organizational structures becomes more viable if the pool of available labor is trained with these goals in mind.
3. Information transfer on the advantages of "good practice" examples of skill-oriented patterns of work organization should be systematically encouraged to convince hesitant companies.

Beyond these specific policy measures, the German government should more generally broaden its focus when it comes to preparing for the future of work. The dominant focus on technological innovation and industrial policy should be expanded to include innovations in work design so that, by engaging in meaningful and skill-oriented work, workers benefit from the digital transformation.

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