Digital technologies make work more demanding

FELIX LUKOWSKI
Research Associate on the BIBB Establishment Panel on Qualification and Competence Development in the "Sociology and Economics of Vocational Education and Training" Division at BIBB

CAROLINE NEUBER-POHL
Research Associate in the "Qualifications, Occupational Integration and Employment" Division at BIBB

Although ongoing digitalisation of the production and of the service sector is stoking fears of job losses, there are indications that the overall effect on employment will be relatively slight. In fact, the main expectation is that the nature of work will fundamentally change. As the use of digital technologies increases, employees will be able to carry out more demanding tasks. This article uses data from a current additional survey of the BIBB Establishment Panel on Qualification and Competence Development to investigate the impacts of the deployment of digital technologies from firms' point of view.

Substitution or new requirements?

The predominant assumption in the relevant literature is that in future new digital technologies and media will be increasingly able to replace human work in the execution of repetitive tasks that are easily programmable (cf. Autor et al. 2003). Because the programmability of tasks which require skill, the handling of "irregular objects"[1] as well as social and creative intelligence is limited (cf. Frey/Osborne 2016; Tiemann 2016), such activities should grow in importance in the wake of the technological shift. Many studies are currently examining this approach by looking at the potential substitutability of humans by machines. Despite technological progress, no massive collapse in employment has been discernible thus far. Autor (2015) explains this by stating that machines complement human tasks in a wide variety of ways rather than merely replacing them. Like Spitz-Oener (2006) before him, he also points out that the essential development will be a change in the *task contents* of employees. Technology is making work more complex. The long-term forecasts that have emerged from the BIBB/IAB qualifications and occupational field projections also indicate that digitalisation will exert a relatively small effect on employment development in purely quantitative terms however labour demand will shift towards more complex tasks (cf. Wolter et al. 2016). This article will examine this result from the perspective of firms and illustrates the extent to which the deployment of digital technologies in companies is already associated with higher requirements for employees. It also presents the tasks which particularly define requirements in the workplace. This provides indications as to how likely human work is to decline in significance as digitalisation continues to advance.

The data base

In order to derive the requirements for employees, we began by looking at the profiles of tasks exercised. The analysis uses data from an additional survey of the BIBB Establishment-Panel on Qualification and Competence Development (BIBB Training Panel) in 2016 (cf. Information Box), in which information on the task profile of workers

BIBB Training Panel

The BIBB Training Panel is a regular annual survey which has been conducted since 2011. It is used to collect representative longitudinal data on the training activities of companies in Germany. Since the 2014 wave of the survey, around 3,500 firms have been taking part. Selection takes place via a disproportionately stratified sample of the statistical population of all companies with one or more employees subject to mandatory social insurance contributions. The questionnaire used each year includes questions on the filling of training places, company recruitment activities and advanced and continuing training measures.

The analysis forming the object of the present article uses data gathered from an additional survey carried out in 2016 via computer-assisted telephone interviews (CATI) with 3,500 companies. This survey especially encompassed detailed questions on the technological status of companies.

[1] Frey/Osborne (2016) make reference to the processing and handling of inconsistent objects which cannot be easily recognised or read by a machine and in general terms to work in an unstructured environment that is subject to frequent change.

and on the use of digital technologies at the surveyed companies was collected. In order to gain information on the technological status of companies, the survey included questions about the types of digital technologies they deploy.

The particular advantage of using data from the BIBB Training Panel is that the views of company owners, managing partners and – at larger firms – executive managers are heard. It therefore delivers information on how entrepreneurs and HR decision makers assess task contents. This could potentially lead to a bias of the results if the way in which the latter view task characteristics deviates starkly from the perception of the employees. Nevertheless, the employers' view of the staff task profile is ultimately the one which is considered in human resources planning at the company, providing valuable indications as to how employers perceive task requirements.

The task requirement index

Before moving on to investigate the correlation between task requirements and the use of digital technologies, the requirements for employee groups at the surveyed firms from the point of view of the human resources decision makers were identified. The latter were asked to consider different employee groups – workers performing simple, qualified and highly qualified tasks – and to state the frequency with which workers carried out repetitive, manual, interactive and knowledge-intensive tasks on a scale of 1 "never" to 5 "very often". A principal component analysis (cf. Information Box) was then used to reduce the total of eight items (cf. Table) to a small number of components which bundle the information of these variables and map their relationship to one another. The starting point is the assumption that repetitive tasks tend to be highly associated with lower requirements and that knowledge-intensive tasks tend to correlate with higher requirements. Because only the first component (of a total of five to be considered) corresponds to this assumption, this component is selected as the index of task requirements and is used during the further approach.[2] The overall KMO criterion of 0.91 (cf. Table) attests a "marvellous" fit of the variables (cf. Kaiser 1974) for a principal component analysis.

The component loadings of the individual variables reveal how much influence the respective variables exert on the index value. In accordance with our assumptions, the loading reflects the fact that frequent execution of repetitive tasks lowers the index value whereas the exercising of knowledge-intensive activities increases the value. The table illustrates that a frequent performance of manual tasks has a positive effect on the index. Pfeiffer/Suphan (2015) point out that the operation of machines is in particular often viewed as a routine task, which is expected to be increasingly replaced by computers, even though such tasks are certainly demanding and complex. This finding is supported by the principal component analysis.

The exercising of interactive tasks corresponds to positive loadings of 0.48 and 0.49, respectively the strongest influence on the value of the requirements index. This shows that the requirements profile is crucially defined by social competencies and even more so than by knowledge-intensive tasks. Another interesting aspect is that programmable tasks influence the index value considerably less than assumed within the scientific discourse, the loadings in this regard being -0.12 and -0.13. From companies' point of view, the average influence of knowledge-intensive and interactive tasks on the level of task requirements is actually around four times higher than for repetitive tasks. This concerns tasks which place demands on the social and creative intelligence of employees. As described at the outset, these tasks differ from repetitive tasks in that they can only be taken on by machines to a limited extent. This suggests that, from the company perspective, changed requirements mainly arise from the new interplay between humans and machines and are not so much a result of the substitution of machines for employees.

The principal component analysis

The principal component analysis (cf. Jolliffe 2002) is a dimension reduction procedure. It generates so-called principal components from a number of variables. These principal components reflect common information and are able to explain the variation in the variables. A principal component analysis uses a number of variables to produce precisely the same number of components. The initial components already explain most of the variation. Generally, only components which explain more variation than the original variables are taken into account (Kaiser criterion, cf. Kaiser/Dickman 1959). In this way a multitude of variables can be represented by using a relatively small number of components. The component loading states how much information is gained from the underlying variables. The loading, thus, corresponds to the weighting with which the variables influence the relevant principal component. Values range between -1 and 1. The suitability of a certain group of variables for a principal component analysis can be judged on the basis of the Kaiser-Meyer-Olkin criterion (KMO criterion, cf. Kaiser 1974), which assumes values of between 0 and 1. Values greater than 0.5 are deemed to be acceptable.

Influence of the use of technology on task requirements

After observing which tasks particularly define requirements in the workplace, we now investigate the extent to which task requirements increase due to the use of digital technologies within the company. On the one hand, this in-

[2] The first extracted component explains 33.81 % of the total variance of the underlying variables.

Table

Component loadings of the task characteristics*

Category	Item	Component loading	KMO criterion
Repetitive programmable tasks	"Tasks for which all details are pre-stipulated"	-0.12	0.82
	"Tasks in which processes are repeated in every detail"	-0.13	0.83
Manual tasks, perception and handling	"Tasks for which they use tools or operate machines such as control or computer systems"	-0.22	0.91
	"Tasks for which they use dexterity and craft trade skills"	-0.20	0.91
Interactive, social tasks	"Tasks in which they inform or advise customers or patients"	-0.48	0.93
	"Tasks which involve persuading others and negotiating compromises"	-0.49	0.92
Knowledge-intensive, creative tasks	"Tasks in which they organise processes or conduct research"	-0.49	0.93
	"Tasks in which they improve or pilot procedures and processes"	-0.41	0.92
Total			**0.91**

* Explained overall variance of the components = 33.81 %, n = 7,894. Because task profiles were surveyed for three employment groups at different qualification levels, a company may exhibit up to three task profiles. These were weighted in accordance with the respective proportion of the employment group.

Source: Additional survey of the BIBB Training Panel 2016, own calculation.

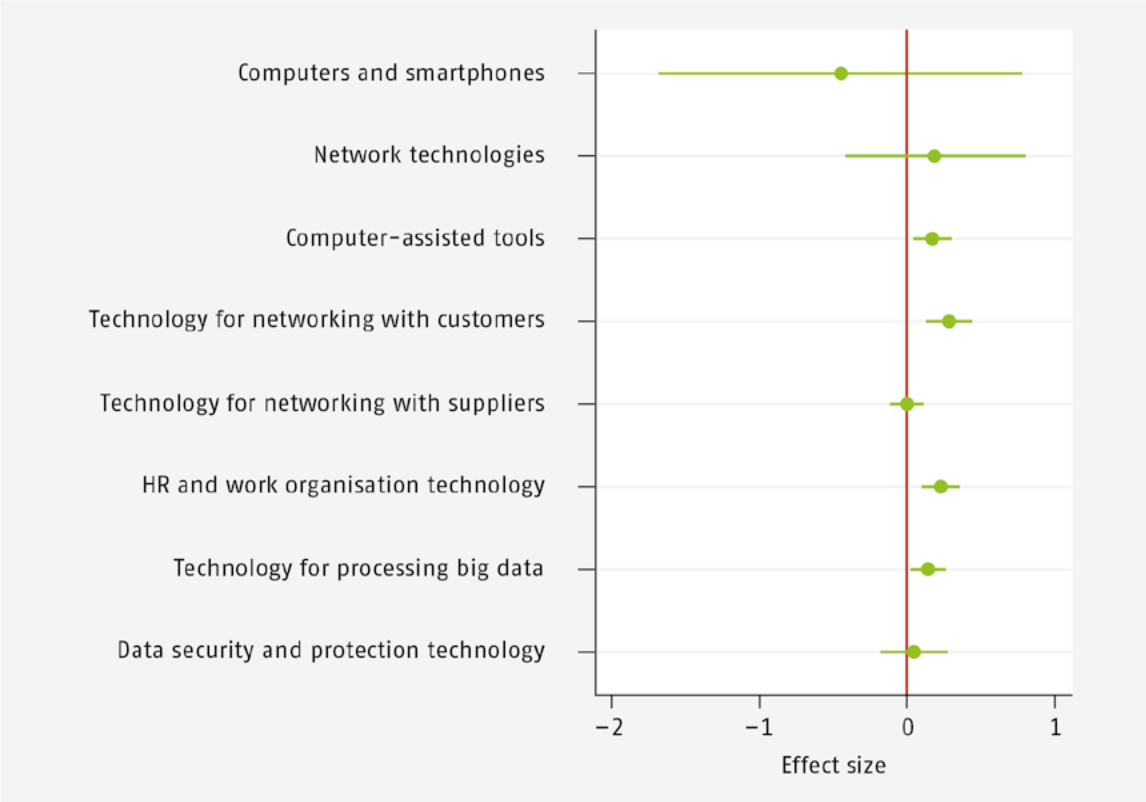
volves a consideration of established digital technologies such as computers, smartphones and network technologies (e.g. the Internet and email). On the other hand, we also enquire into technologies, which are associated with the increasing digitalisation of trade and industry because of their constant further development. These encompass computer-assisted tools (e.g. CNC machines or cyber physical systems), technologies for networking with customers (such as a company's own Internet presence or the use of social media), technologies for networking with suppliers (for instance via the use of ERP systems), technologies for human resources and work organisation (e.g. HR facility management tools), technologies for processing of large quantities of data (e.g. cloud computing) and technologies for data security and data protection.

The result of the regression analysis conducted for this purpose is presented in the Figure (p. 8). The plotted points show the value of the coefficients, i.e. the effect which the individual types of technology have on the requirements in the company. The further away a point is from the red zero line, the stronger the effect. The horizontal lines plot the relevant confidence interval. If the latter includes the zero line, no significant correlation exists between the technology and the task requirements level.

The results show that computer-assisted tools, technologies for networking with customers, technologies for human resources and work organisation and technologies for processing of large amounts of data all significantly increase requirements for employees from companies' point of view. In this context, this indicates that fewer repetitive routine tasks, more manual tasks, and in particular more interactive and knowledge-intensive tasks, are performed by employees in companies at which such technologies are deployed. Although technologies such as computer-assisted tools facilitate work, by the same token they require higher cognitive and manual skills to control the machines. The existence of an internet presence with product listings and ordering or reservation systems also places higher cognitive demands on employees. The use of social media opens up new opportunities for customer communication, which brings about an increase in interactive tasks. Technologies for HR and work organisation and for the processing of large quantities of data simplify administration and the handling of available data. Notwithstanding this, their evaluation and interpretation of such data present employees with new tasks that require relevant cognitive skills. Because there is a decrease in administrative tasks, more time is created for interaction with other employees and/

Figure

Influence coefficients of selected digital technologies on the task requirements index



Source: Additional survey of the BIBB Training Panel 2016, own calculation, dependent variable: Task requirements index, n = 1,765, control for industries, company size, region, participation in training, qualifications structure, investment volume and the proportion of investments in digital technologies. The horizontal lines reflect the 95 % confidence interval.

or customers, thus placing a greater focus on interpersonal activities.

Computer and smartphone use and the use of network technologies such as internet access or email do not exert any significant influence on the task requirements. The reason for this is that these technologies are already present in 95 per cent of the companies, and their use is no longer perceived to be special or demanding. This high degree of penetration is also an explanation for the fact that technologies for data security and data protection do not exhibit any significant effect because they are already deployed in 88 per cent of the companies. Nevertheless, data security is at the same time one of the major issues of the "Smart Industry" because new networking technologies may also offer new points of attack for the circumvention of security measures. This means that in future the focus will be on the degree of security provided by the relevant technologies rather than merely on their presence. This should be a relevant topic of further research. Surprisingly, networking with suppliers does not have any significant effect on the requirements level. There are indications that these technologies frequently appear in typical combinations with other technologies, meaning that their separate effect is not measurable by means of this analysis. Here, as well, further research is needed.

With the exception of the technologies for data security and for networking with suppliers, all Smart Industry technologies, thus, exert a significant positive influence on employees. A continuous rise in requirements is, therefore, to be expected should the degree of use and influence of these technologies be further expanded in the wake of digitalisation.

However, the results from a simple regression analysis such as the one conducted here should not be interpreted as causal. The presence of other omitted variables influencing the task requirements index, which bias the size of the effect of the various technology types, cannot be excluded. Although this problem has already been addressed by controlling for structural differences in the task requirements by industries, company size, region, qualifications structure, participation in training and investment behaviour of the companies, the strength of effects of the respective technologies should be judged with caution. The results merely show an existing correlation (cf. Angrist/Pischke 2008), but still offer valuable indications in this regard.

The machine remains a tool

In summary, the analysis described enables us to confirm that, from the companies' perspective requirements for employees will increase as a result of digitalisation. If computer-assisted tools and technologies for networking with customers, for human resources and work organisation and for the processing of large amounts of data are deployed in the company, employees on average carry out more demanding tasks. In individual terms, this means that employees at such companies perform fewer repetitive routine tasks and more manual, knowledge-intensive and subject-related tasks. Because the use of digital technology already correlates with higher requirements, the expectation is that dealing with complexity will become increasingly important for employees in the wake of digitalisation. Increasing complexity primarily means that greater significance will be attached to the social and creative intelligence of employees. This concerns tasks in which machines act as tools because, in contrast to repetitive tasks, such activities cannot (according to the current status of technology) be fully taken over by machines. The consequence of this for the debate on digitalisation would be that the complementarity of human and machine should be of focus rather than their substitutability.

The presented results provide valuable initial information on how digital technologies influence the requirements profiles of employees. Quantifying the findings, and analysing the precise scope of the cooperation between labour and machinery, as well as their degree of substitution offer a highly interesting field for future research. ◀

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