Technology adaption, employment stability and wage changes
Worker-level Evidence from Germany

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The tremendous pace of advances in robotics and artificial intelligence and their rapid penetration across all developed countries and industries keeps the debate going if automation causes unemployment and wage inequality. Using novel linked employer-employee data for Germany, we provide employment and wage effects of digitalization within firms on the existing workforce. We contribute to the literature unique empirical evidence on the role of digital technology in shaping heterogeneous labor market experiences of individuals across several dimensions such as gender, education and occupational tasks. Our high-frequency micro-data reveal important heterogeneous effects that explain macroeconomic phenomena such as wage dispersion and heterogeneities in the labor market participation.

In recent years, the rapid emergence of new technology such as machine learning, artificial intelligence, and mobile robotics have raised concerns that human employment will be obsolete and has led to an intense debate about the societal impacts of automation. The pessimistic view of early estimates predicting new technology will take over large parts of human work by replacing a very high percentage of existing occupations (Frey and Osborne 2017), has stimulated a large number of empirical studies to investigate the labor market effects of automation. Numerous studies considering the adoption of industrial robots, find negative employment and wage effects (Acemoglu and Restrepo 2017; Borjas and Freemann 2019; Giuntella and Wang 2019). Borjas and Freeman (2019, p.2) conclude that "robots are coming and they are going to massively transform the world of work." On the contrary, studies (Autor 2015; Autor et al. 2015; Gregory et al. 2016; Arntz et al. 2017; Dengler and Matthes 2018) show that the negative effects are overestimated. First, they do not take into account that job activities vary across individuals within the same occupation. Second, human labor is more flexible than capital-intensive automation technology, thus humans have an advantage in performing emerging novel tasks. Taking these two mechanisms into consideration, the substitution potential of occupations and the negative labor market estimates shrink significantly. Therefore, the debate about the 'future of work' is in full-swing. The paucity of data providing a direct measure of digital technology keeps the discussion going as rough approximation measures for automation lead to contradicting results. The empirical literature so far either tries to approximate technological developments with changes of routine-intensity (see, e.g., Autor et al. 2015; Gregory et al. 2016; Cortes and Salvatori 2019) or the diffusion of industrial robots in the last decades (see, e.g., Acemoglu and Restrepo 2017; Borjas and Freeman

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2019; Dauth et al. 2017; Graetz and Michaels 2018). A drawback of using routine intensity as a measure for technological changes is the simultaneous presence trade, demographics or simply organizational changes. A common caveat of the robots measure is its' restriction to industrial robots ignoring other automated machines in manufacturing or robots and machines in other sectors e.g. service robots. Moreover, it is often unclear if observed shifts in labor market outcomes are associated with technologies that are prevalent since one, two or three decades (like computers) or to the most recent, advanced technologies like AI, mobile robotics, analytic tools for Big Data, the Internet of Things or Cyber-Physical-Systems. These technologies are called `4.0-technologies' following the idea of a 4th industrial revolution in which the digital and the physical sphere are linked (Schwab 2017). Since it is very difficult to separate these effects from one another and not least due to the different data sources, it is not surprising that the empirical literature finds different effects on employment and wages.

The concern about technology driven labor market effects has also been addressed in theoretical economic frameworks. Several task-based approaches (Acemoglu and Autor 2011, Benzell et al. 2015, Acemoglu and Restrepo 2018a) illustrate that the aggregate net effect of new digital technologies is ambiguous as the displacement effect (labor demand reducing) might be offset by a productivity effect (labor demand increasing). Even the inclusion of novel tasks does not provide a clear theoretical prediction for employment and wage effects of new technology (Acemoglu and Restrepo 2018a).

Up to now, there are no clear results how latest digital technologies affect the employment stability and wage development of the existing workforce. The scientific community highlights the need for empirical evidence about the impact of digitalization and automation technology on employment and wages (Acemoglu and Restrepo 2018b, Agrawal et al. 2019, Bessen 2018). This paper contributes to the literature direct employment and wage effects of digital technologies within establishments. Using a novel linked employer-employee data for Germany this paper estimates the employment and wage effects on workers when their firm invests in digitalization technology. We link the "IAB-ZEW Labour Market 4.0" Establishment Survey to German Social Security Data and the occupational expert database BERUFENET. The administrative establishment and worker data is provided by the Institute for Employment Research of the Federal Employment Agency of Germany. The uniqueness of our establishment data is a direct measure of firms' investment into 4.0 digital technologies between 2011 and 2016. The survey was conducted for both service and manufacturing firms which enables us to first investigate the impact of digitalization across different sectors including service. The direct technology measure allows to differentiate between production and office and communication technologies. For each type we observe the automation degree of the work equipment which enables us to compute technology-specific capital stocks for each firm. Furthermore, the detailed high-frequency micro-data observe individual workers on a daily basis. Thus, we are able to follow workers not only across different establishments but also across different labor market states. This allows us to investigate the impact of technology investments on individual labor market histories in a depth that is so far unique in empirical literature. Our empirical approach is to estimate individual-level fixed effect regressions and address time varying establishment- and worker-characteristics by including a battery of control variables. All time invariant characteristics are removed by our approach. To identify the effect of digital technologies on wages, we estimate mincer type wage regressions with daily wages being the outcome of interest and the key explanatory variable for our analyses is the technology-specific capital stock. We capture the employment effect by estimating multinomial logit regressions.

We find that investments into 4.0 digital technologies do not expose individuals to higher likelihood of separations from their initial employment. Increasing digitalization within establishments is not related with lower employment stability for the workforce. Differentiating across occupational tasks shows that routine workers and workers conducting non-complex tasks have the highest probability of remaining employed in establishments which are not investing into new digital technologies. Moreover, results from individual-level fixed effects estimates suggest

investment into 3.0 and 4.0 digital technologies are associated with positive wage increases whereas investment into old conventional technologies lead to wage losses for the existing workforce. We find heterogeneous labor market prospects across occupational task groups. Individuals conducting routine intensive occupations are most likely to remain employed in firms not using any digital technologies, however, this subgroup benefits the most from occupational switches within the establishments in terms of wages. Thus, our results underline the importance of internal training and lifelong professional development in order to guarantee that all individuals can keep up with technological progress.

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