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Digitalisation, Gender, and Training of Employees in the Second Half of Working Life in Germany****

Abstract: Digitalisation places new demands on employees working in changing occupations. To undertake the adaptation to new requirements further training is one central strategy of updating and building new skills – especially for older employees. Digitalisation in the world of work has been shown to affect male and female employees differently. However, little is known about the interrelationship between digitalisation in occupations and training. This gap is addressed by investigating (1) the association of training participation and the extent of digitalisation in their occupations of employees in the second half of working life and (2) whether there is a gender difference in this association. In addition, these questions are investigated regarding the employee's desire to participate in future training. Using data from the German Ageing Survey, logistic regressions are applied to control for sociodemographic, labour market and work-related characteristics of employees aged 43 to 65 in Germany. Positive associations between a change in the level of digitalisation in occupations and (the desire for) training participation are found. The more pro-

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Code and data availability: The data analysis of this article was conducted in Stata 15. The code is available at the Research Data Centre of the German Centre of Gerontology (FDZ-DZA) upon request. Also, data of the German Ageing Survey is available for the scientific community at the FDZ-DZA upon request: https://www.dza.de/forschung/fdz/. Data on the digitalisation level of occupations was published in O'Kane et al. (2020) and used in this article with kind permission of Bertelsmann. Data on the gender composition of occupations were determined by Stuth (2022) and are available on request at the CESSDA Data Catalogue (CDC): https://datacatalogue.cessda.eu.

nounced the change in the digitalisation level in occupations, the more female employees seem to be disadvantaged in training participation compared to men.

Keywords: Digitalisation; Gender; German Ageing Survey; Older Employees; Skills;Training

Digitalisierung, Geschlecht und Weiterbildung von Arbeitnehmenden in der zweiten Hälfte des Arbeitslebens in Deutschland

Zusammenfassung: Die Digitalisierung stellt neue Anforderungen an Arbeitnehmende in sich wandelnden Berufen. Damit die Anpassung an neue Arbeitsanforderungen gelingt, kann Weiterbildung die zentrale Strategie für die Ausbildung neuer Kompetenzen sein – insbesondere für ältere Arbeitnehmende. Die Digitalisierung in der Arbeitswelt wirkt sich unterschiedlich auf männliche und weibliche Arbeitnehmende aus. Bislang gibt es jedoch wenig Literatur zu der Beziehung zwischen der Digitalisierung in Berufen und der Teilnahme an Weiterbildungen. Dieser Artikel schließt diese Lücke und untersucht, (1) ob es einen Zusammenhang zwischen der Weiterbildungsbeteiligung und dem Ausmaß der Digitalisierung in den Berufen von Arbeitnehmenden in der zweiten Hälfte des Arbeitslebens gibt und (2) ob es einen Geschlechterunterschied in diesem Zusammenhang gibt. Darüber hinaus werden diese Fragen im Hinblick auf den Wunsch der Arbeitnehmenden, an zukünftigen Weiterbildungen teilzunehmen, untersucht. Auf Basis von Daten des Deutschen Alterssurveys werden logistische Regressionen geschätzt und für soziodemografische, arbeitsmarkt- und beschäftigungsbezogene Merkmale von Arbeitnehmenden im Alter von 43 bis 65 Jahren in Deutschland kontrolliert. Es zeigen sich positive Zusammenhänge zwischen einer Veränderung des Digitalisierungslevels in den Berufen und der (gewünschten) Weiterbildungsbeteiligung. Je ausgeprägter die Veränderung des Digitalisierungslevels in den Berufen, desto stärker scheinen weibliche Beschäftigte in der Weiterbildungsbeteiligung gegenüber Männern benachteiligt zu sein.

Stichworte: Digitalisierung; Geschlecht; Deutscher Alterssurvey; Ältere Arbeitnehmende; Kompetenzen;Weiterbildung

1 Introduction

Digitalisation has and continuously will alter the world of work, placing new occupational demands on employees (Acemoglu/Autor 2011; Autor et al. 2003; Frey/Osborne 2017). In view of rapidly changing skill demands due to digitalisation[1]

1 The world of work has been transformed by technological progress ever since. However, the recent process of technological transformation, namely digitalisation, is characterised by its

further training becomes increasingly important to avoid skill mismatches in order to maintain employees' productivity and employability (Brunello/Wruuck 2021). This particularly affects employees in their second half of working life, since their skillset is more likely to become obsolete or misfit new requirements compared to younger employees, because digital skills were not a regular part of their initial occupational education and training. Indeed, digital skills seem to be negatively associated with age (Curtarelli et al. 2017; Hargittai 2002, Morris/Brading 2007; Vasilescu et al. 2020). Moreover, older workers assess their digital skills worse compared to younger workers (Czaja et al. 2006; Vasilescu et al. 2020). Employers hold a similar assessment of older and younger employees' digital skills (Van Dalen et al. 2009). However, investments in building new skills may be less attractive for older employees in light of impending retirement.

In addition to digitalisation, the demographic trend of an increasingly ageing workforce puts the German welfare state and labour market under pressure, as the share of labour market participants in the total population decreases, the average age of labour market participants increases and shortages of skilled workers in certain industries or occupations rise (Buchholz et al. 2011). To counteract these developments, the German government has implemented some political measures to prevent early retirement and promote lifelong learning (e. g. the gradual increase of the statutory retirement age (§ 7a SGB II) or the launching of the national skills strategy (BMAS 2021)). However, such political measures will fall short if opportunities for training participation are not equally distributed among employees and job-related training is often discussed as an important factor in persisting gender differences in the labour market (Dämmrich et al. 2016; Havet/Sofer 2008).

If training is paramount to address challenges of digitalisation of work and the aging workforce it is important to shed light on whether male and female employees in their second half of working life have equal opportunities to adapt their skills to new requirements. From a gender-perspective, current research views digitalisation and related transformation processes in the world of work as a 'window of opportunity' for a renegotiation of gender power relations and as a risk of exacerbating gender differences (Carstensen 2020a; Howcroft/Rubery 2019; Kohlrausch/Weber 2021; Krieger-Boden/Sorgner 2018; Piasna/Drahokoupil 2017; Wajcman 2004, 2009). On the one hand, digitalisation is viewed as an opportunity to empower women and de-segregate labour markets. Digital communication tools may enable and facilitate the reconciliation of paid and unpaid labour, possibly paving the way for women to enter new employment forms or occupations (Carstensen 2020a). However, childcare responsibilities are found to be negatively associated with training participation for female but not for male employees

extraordinarily high speed of innovations and the wide range of tasks that can be substituted or changed by new, digital technologies (Brynjolfsson/ McAfee 2014). In the literature, digitisation is even regarded as having a disruptive or revolutionary character (Brynjolfsson/ McAfee 2014; Hirsch-Kreinsen/ Wienzek 2019; Murawski/ Bick 2017; Schwab 2017).

(Dieckhoff/Steiber 2011). On the other hand, digitalisation may exacerbate gender differences in the labour market. New jobs, employment forms or working conditions that raised in course of digitalisation, like 'gig' or 'platform work' and 'working from home', may additionally disadvantage women (Piasna/Drahokoupil 2017) if they are similar to non-standard employment, which provides poor job quality, low employment security, missing working time regulations, low wages, and low training participation (Brehmer/Seifert 2008; Grund/Martin 2012). To date, women are more often engaged in non-standard employment than men, which is often attributed to their greater involvement in unpaid work compared to their male counterparts (Bachmann et al. 2020). In addition, if a woman in a household is working from home, the unequal distribution of care work responsibilities is even found to increase (Carstensen 2020b). Irrespective of the previous researchers take on digitalisation as a chance or as a risk for women in the labour market, there is a broad consensus that training is the central strategy in adapting employees' skills to new and changing demands (BMAS 2021; Goldin/Katz 2008; OECD 2019a, 2021; Oesch 2013).

Digitalisation processes affect employees differently as only some occupational tasks can be substituted by digital technologies, while others can be complemented or are not affected at all by digitalisation (Autor et al. 2003).[2] Indeed, the task content within occupations has changed remarkably over the last years (Atalay et al. 2020; Spitz-Oener 2006). In particular, employees in occupations that strongly rely on advanced technologies seem to have experienced more changes in their task profiles (Spitz-Oener 2006). Studies on automation risks respectively the share of routine-tasks in occupations find lower training participation among workers with high automation risks respectively a high share of routine tasks in their occupations (Görlitz/Tamm 2015; Ioannidou/Parma 2021; Nedelkoska/Quintini 2018; OECD 2019b). Literature examining training participation over time finds increasing participation rates in Germany (Becker 2019; BMBF 2021). However, it is not clear if this trend is induced by digitalisation. Literature that directly examines the association between the penetration of digital technologies in occupations and training suggests a positive association between employees' training participation and digital technologies in the company (Gashi et al. 2010; Lukowski et al. 2021; Wotschack 2020). Lukowski et al. (2021) report that a higher share of digital technology users in firms is associated with higher training provision. Gashi et al. (2010) observed higher training intensity when new technologies are introduced to the workplace, and when workplaces have experienced difficulties recruiting skilled workers. Wotschack (2020) finds investments in information and communication technologies (ICTs) and modern production or service technologies associated with

2 It is important to highlight, that digital technologies are not implemented whenever technical feasibility for task substitution is given (Dengler/ Matthes 2018; Valenduc/ Vendramin 2017). Other factors such as ethical considerations, the relative advantage of human labour, or legal issues can hinder the introduction of digital technologies.

a higher probability of firms to invest in training. However, he also finds that higher training participation rates are not to be found among low skilled workers. These findings complement the more general findings that lower education or lower skills of employees are related with lower training participation (Cedefop 2016; Grund/Martin 2012; OECD 2021). Moreover, we are not aware of a study directly examining digitalisation and gender differences in training participation.

In the literature on training in general there is no consensus on whether there is a gender-training gap or not (Wotschack 2019). Some studies find that women are more likely than men to participate in training (BMBF 2021 (GER); Cedefop 2016 (EU); Jones et al. 2008 (GBR)), some find that women are less likely to participate in training (Aisa et al. 2016 (ESP); Burgard 2012 (GER); Dieckhoff/Steiber 2011 (EU); Pischke 2001 (GER); Wozny/Schneider 2014 (EU)), and other studies find no gender training gap at all (BMBF 2019 (GER)).[3]

In recent literature the importance of organisational characteristics, like firm size or presence of human resource strategies, as determinants for training participation is emphasized (Grund/Martin 2012; Wotschack 2020). Large enterprises may profit from larger financial and personal resources and may therefore be able to provide employees better with structured internal training programmes. Also working in the public sector is related with higher training participation compared to working in the private sector (Schömann/Becker 1995). In Germany women are more often employed in the public sector than men (DBB Beamtenbund und Tarifunion 2021). However, highly digitalised occupations – like occupations in the ICT sector – are associated with a higher training provision but are predominantly male-dominated (O'Kane et al. 2020; OECD 2018).

Therefore, this article aims to answer the following questions: (1.a) is participation in training higher among employees aged 43 to 65 years working in occupations with a higher degree of digitalisation? And (1.b) does participation in training differ between men and women in relation to the degree of digitalisation in occupations? Furthermore, regarding employees' preferences for training participation: 2.a) is there a greater desire for training among employees in the second half of working life working in occupations with a greater degree of digitalisation? And 2.b) do male and female employees differ in this regard?

In this article, training is defined as job-related continuing vocational training or retraining of any kind, regardless of financing source, duration or time frame. This includes courses, seminars or other events serving employees' continuing vocational training or retraining. It does not include learning activities that are part of an educational programme or learning on the job. The focus is on employees in their second half of working life, which is defined by the age range 40 to 65 years, to

3 These varying findings – even for Germany – may result from varying definitions, operationalisations and analyses of employees' participation in training.

focus on employees whose initial education and training is probably outdated with regard to the digital technologies in their occupations.

To investigate training participation, it is necessary to look at employees' and employers' perspectives. One theoretical approach that does that is the human capital theory (HCT). For employees, training is interpreted in HCT as an investment in their human capital – their economically viable skills and knowledge (Becker 1975; Lewis et al. 2008). Employee training improves or maintains productivity and increases wages and job security. To avoid decreasing or stagnating productivity and skills shortages, employers should provide their employees with opportunities for training when employees' occupations become more digitalised. Similarly, employees should be interested in counteracting a devaluation of their human capital that is likely to progress faster in more digital occupations. However, educational decisions are not solely the result of rational cost-benefit considerations, because cost-benefit considerations are heavily influenced by employees' social class and class-specific lifestyles and dispositions (Boudon 1974; Bourdieu/Passeron 1971; Breen/Goldthorpe 1997; Esser 1999). Class-related normative values, privileges or constraints related to successful participation in training may shape employees' training decisions and aspirations. For the abovementioned reasons, it can be assumed that training participation and willingness to participate in training is higher for employees working in occupations that are digitalised to a greater extent.

(H1.a) The higher the extent of digitalisation in an occupation, the greater the likelihood of training participation.

(H2.a) The likelihood of desiring training participation increases, the higher the degree of digitalisation in an employees' occupation.

Furthermore, the HCT assumes different investment rationales for men and women due to differences in time allocation (Becker 1975). Women in Germany are (still) mainly responsible for the majority of unpaid house- and care-work. This imbalance in the provision of unpaid care work still exists among men and women in the second half of life (Ehrlich/Kelle 2019; Klaus/Vogel 2019). Hence, they have less time available for paid work, training and experience more care-related career interruptions. Employers might therefore be less inclined to invest in the human capital of female employees because of the lower probability and longer amortisation periods until investments in training will pay off, compared to men. Taste-based or statistical discrimination may reinforce employers' gendered training preferences (Arrow 1974; Becker 1971; Phelps 1972), which may also be reinforced if the training includes digital skills. Therefore, HCT expects women to show weaker (desire for) training participation. A lower probability for women to participate in employer-provided training might also have its origin in women's preferences. Due to the higher probability of career interruptions, women tend to invest in general skills which are applicable in diverse settings and have low decay rates (Becker 1991; Estevez-Abe 2005; Polachek 1981). Some studies indicate that

embodied gender stereotypes cause women to have a lower assessment of their digital competencies and to be less open to new technologies (Cai et al. 2017; Initiative D21 2021). Therefore, women's willingness to participate in training in highly digitalised occupations is assumed to be lower than men's.

(H1.b) Women experience a flatter increase in the likelihood of training participation than men do with increasing digitalisation in an occupation.

(H2.b) The increase in the likelihood of the desire to participate in training is flatter for women than for men with increasing digitalisation in an occupation.

2 Method

2.1 Data and Sample

To answer the research questions, data from the 2017 wave of the German Ageing Survey (Deutscher Alterssurvey; DEAS) was used (Klaus et al. 2017). The DEAS is a cross-sectional and longitudinal survey based on computer-assisted personal interviews and is representative for the population aged 40 and above living in Germany. It contains rich information on the living and working situations, as well as attitudes or wishes regarding different aspects of life of people in the second half of life aged 40 years and above. Information on the extent of digitalisation in employees' occupations came from an external source and was matched with DEAS using the International Standard Classification of Occupations 2008 (ISCO-08). Digitalisation was measured in two ways: first, the relative level of digitalisation of employees' occupations in 2018 and second, the change in the digitalisation level of employee's occupations experienced between 2014 and 2018, determined by Bertelsmann and Burning Glass Technologies for Germany (O'Kane et al. 2020).

The sample contained employees aged 43 to 65 working full- or part-time or in irregular or marginal employment in Germany at the time of the interview. Therefore, self-employed people, civil servants,[4] liberal professions, farmers and foresters were excluded from the sample.[5] Employees who had missing information on variables considered in the analysis were also excluded. The final sample comprised n = 1,020 employees, whereof 47.53 percent were women, 40.29 percent had a high educational level and the mean age was 52 years (SD_{age} = 5.469) (see table 1).[6]

4 In Germany civil servants are not regular employees because they are subject to special working conditions rooted in the Basic Law (Art. 33 para. 4 & 5 GG). Analyses including the group of civil servants have led to similar findings to those presented in this article.

5 Since the DEAS 2017 is a panel wave only and the last refreshment sample was drawn in 2014, the youngest employees in the sample are 43 years old.

6 The final sample to analyse the employees' desire to participate in training comprised n = 1,018. For the sake of clarity and since there are no major differences, the sample description refers to the analysis sample for training participation (n = 1,020).

Table 1: Sample Description.

Variable	Range	Categories	Mean / %	SD
participation in training	0|1	no	36.48	0.019
		yes	63.52	
desire to participate in training in future[a]	0|1	no	30.90	0.018
		yes	69.10	
digitalisation level	0–97		52.93	16.837
change in digitalisation level	-13–32		14.74	6.989
gender	0|1	male	52.47	0.019
		female	47.53	
age (years)	43–65		51.86	5.470
residency	0|1	West	85.49	0.010
		East	14.51	
high education	0|1	no	59.70	0.019
		yes	40.19	
gender composition of occupations	1|2|3	female dominated	23.81	0.016
		mixed	39.55	0.019
		male dominated	36.64	0.019
responsible for major part of housework[b]	0|1	no	55.28	0.019
		yes	44.72	
young children in same household[b]	0|1	no	83.52	0.016
		yes	16.48	
working time (h/week)	2–70		37.86	10.982
small enterprise	0|1	no	78.41	0.015
		yes	21.59	
public service	0|1	no	79.63	0.015
		yes	20.37	
years till planned end of work (residuals from regression on age)	-11.5–35.3		-0.27	4.197
career interruption[b] (years)	0–25		2.07	3.820
occupational change during the last 3 years	0|1	no	75.26	0.017
		yes	24.74	

Note: SD = standard deviation. [a] n = 1,018. [b] information from DEAS 2014.

Source: DEAS 2017 (weighted); n = 1,020.

2.2 Analyses

Logistic regression models with maximum likelihood estimations were applied, and partial regression coefficients in log odds metric were reported. The log odds metric

enables the interpretation of the direction and significance of the coefficients. To consider whether the results for employees working within the same occupations are more similar than those for employees working in different occupations, clustered standard errors for occupations (ISCO-08, 4 digit) were applied. Associations were reported as statistically significant at a 95 percent confidence level. To determine gender and digitalisation's role in the (desire) for training participation, three models were estimated. (1) The first model controlled for compositional effects by considering several control variables. (2) In the second model, an interaction term for gender and the digitalisation level was included, as gender differences were assumed to be more pronounced in more digitalised occupations. (3) The third model additionally controlled for an interaction effect of gender and the change in the digitalisation level. For the interaction terms, marginal effects were calculated and plotted (as suggested in Brambor et al. (2006)) to illustrate the effect of gender in dependence of the (change in the) digitalisation level on employees' (desire for) training participation.[7]

To facilitate interpretation, and in line with Mayerl and Urban (2019), all independent variables were mean centred, except gender and the change in the digitalisation level which already contained a meaningful 0 point. Moreover, all continuous variables were standardised. Whereas most variables were based on the 2017 DEAS wave, some control variables, such as responsibility for the major part of housework, were taken from the 2014 DEAS wave, because they were not time-invariant and might have been decisive in employees' training participation in the following years.[8] Additional analyses were performed (1) using a randomly drawn subsample (80 percent), (2) a subsample of 50- to 65-year-old employees, (3) excluding five occupations with the highest digitalization levels, (4) and excluding five occupations with the highest changes in the digitalization levels. The additional analyses confirming the robustness of the findings from model 3 (see table 11 and 12 in the appendix).

2.3 Dependent Variables

The first dependent variable measures whether employees *participated in at least one training* over the previous three years. Training encompasses all kinds of training that are job or occupation related. The second dependent variable is the employees' *desire to participate in training in the future.* Similar to the first dependent variable, this only refers to job- or occupation-related training. Nearly two thirds of employees (63.5 percent) stated that they had participated in at least one training during the previous three years. More than two thirds (69.1 percent) of employees wished to participate in training in the future (see table 1).

7 An extensive variable description and regression diagnostics are reported in the appendix (see table 4, 7–9 and figure 5 in the appendix).

8 Find correlation matrixes and cross tabulations of the dependent variables separated for gender in the appendix (table 7–9).

2.4 Predictor Variables

Digitalisation and gender were central predictor variables. Digitalisation was measured by two variables: the relative *digitalisation level* of occupations in 2018 and by the *change in the digitalisation level* in the occupations between 2014 and 2018. The digitalisation level indicates, for example, in which occupations the most/least digital skills were demanded by employers in 2018. The change in the digitalisation level indicates which occupations experienced an increase or decrease in the digitalisation level between 2014 and 2018.[9]

The digitalisation measures are based on job postings scraped from online job boards and company websites (O'Kane et al. 2020).[10] A machine-learning model was used to derive data from the job posting text, such as information on occupations or skills. Duplicate postings were removed. The scraped data contains information on 3,111 distinct skills assigned to five skill types ranging from "not digital skills" to "ICT technical skills". To acknowledge differences in digital proficiency among skills, weights were assigned to the skill types. Based on this data, the digitalisation level was built by summing up the average recall for every weighted skill for each occupation, taking the logarithm, and normalising the values to range between 0 and 100. The change in the digitalisation level ranges from -13 to 33, with 0 indicating no relative change in the digitalisation level between 2014 and 2017.[11] The average digitalisation level in the sample is 52.76 (SD_{DL}: 16.85) and the average change in the digitalisation level is 14.84 (SD_{CDL}: 7.13) (see tab. 1). The digitisation data were provided by Bertelsmann and Burning Glass Technologies (O'Kane et al. 2020) and matched to DEAS data using the information on employees' occupations (ISCO-08, 4 digit).[12] In recent years, scientific interest in job ads data has increased (Mezzanzanica/Mercorio 2019) and is already used in numerous studies (Acemogl Restrepo 2020; APEC 2020; Azar et al. 2020; Deming/Noray 2020; Nania et al. 2019).

Employees' *gender* is based on interviewer's assessments during the face-to-face interviews and added to the analyses as variable that differentiates between "0" for "male" and "1" for "female".[13]

9 To ensure the comparability over time, the 2014 digitalisation value was scaled to be in terms of the 2018 value (see O'Kane et al. 2020). For an overview of occupations in the analysis sample with the highest/lowest (change in the) DL see table 13 in the appendix. For the distribution of women and men across occupations' DL and CDL see figure 6 in the appendix.

10 The job postings have been found to be comparable to EUROSTAT data on the total employment distribution by occupation, industry and region for 2014 and 2017 in Germany (O'Kane et al. 2020).

11 For details on sensitivity tests ran for the skill weights and the construction of the digitisation measures see (Cammeraat/ Squicciarini 2021; Colombo et al. 2019; O'Kane et al. 2020).

12 If occupational information of employees was not available on a four-digit level, the average digitalisation levels for the corresponding occupational major groups were linked to the data.

13 In the few cases where the interviewers were not sure about the gender of the respondents, the interviewers asked the respondents directly and the respondents self-reported their gender.

2.5 Control Variables

Besides the DEAS-sampling variables, age, and region, it is controlled for individuals' education, household responsibilities and several occupational and work-related characteristics. *Age* was measured in years and added as a continuous variable. The employees' *place of residence* was added as a binary variable, with "0" as "living in East Germany" and "1" as "living in West Germany".

The choice of the other control variables was based on theoretical considerations and the existing literature mentioned above. The educational level of employees was considered by adding a binary variable, with "1" for high education (ISCED 5–6) and "0" for low or middle levels of education (ISCED 0–4). Medium and low levels of education could not be differentiated as too few employees reported a low education (ISCED 0–2). To control for gendered differences in care responsibilities, it was considered whether *young children below the age of 13 lived in the same household (1) or not (0)*. To control for a second gendered domain of time use beyond time spent at paid work, a dummy variable with information on *housework responsibilities* was added. All respondents who are either living with other persons in a household but state that they are responsible for the majority of housework, or respondents living alone, were coded as "1". *Working hours* per week including overtime was added as continuous variable to the analyses. Data on the *gender composition of occupations* in Germany was derived from (Stuth 2022), and is originally based on the 2015 German micro-census. The gender composition of occupations is introduced as a categorical variable using mixed-occupations as the base category. In this article, an occupation is defined as female-dominated if the overall share of male employees is below 30 percent, and as male-dominated if the share of female employees is below 30 percent.[14] *Company size* was considered by a dummy variable with "1" for small enterprises with no more than 20 employees. To distinguish between employment in the public or in the private sector a dummy variable with "1" for working in the public sector was added.

The intended remaining time horizon of employees in the labour market was controlled for by employees' *planned number of years till the end of work*. To avoid correlation with age, the residuals from regressing the stated years till the end of work on age were determined and used as a control variable. Employees' *career interruptions* were indicated in years and added as continuous control variable. Lastly, a dummy variable indicating if an employee had *changed his or her job* during the previous three years was added, with "1" indicating professional changes.

Starting with the 2020 survey wave the German Ageing Survey offers a more distinct gender differentiation in "male/female/diverse".

14 These thresholds are commonly used in other studies with a focus on the German labour market (Busch 2013; Dengler/ Tisch 2020).

3 Results

No association between training and the digitalisation level and no gender differences were obtained in model 1, controlling for compositional effects underlying the workforce (see table 2).[15] For an extensive overview of the results including all control variables, see table 5 in the appendix.

Table 2: Digitalisation and Participation in Training of Employees in Their Second Half of Working Life in Germany.

	Model 1	Model 2	Model 3
Digitalisation Level	0.134	0.154	0.148
	(0.122)	(0.124)	(0.120)
Gender (ref.: male)	0.109	0.111	**1.012**
Female	(0.205)	(0.206)	(0.455)
Gender # Digitalisation Level		-0.039	0.003
		(0.213)	(0.195)
Change in Digitalisation Level			**0.270**
			(0.130)
Gender # Change in Digitalisation Level			**-0.418**
			(0.175)
Constant	**0.528**	**0.525**	-0.065
	(0.183)	(0.178)	(0.357)
n	1,020	1,020	1,020
Prob. > χ^2	0.000	0.000	0.000
$R^2_{Adj.\ McFadden}$	0.078	0.078	0.085
AIC	1,274.595	1,276.512	1,271.043

Note: Control variables: age, residency, education, housework, young child in same household, gender composition of occupations, working hours, small enterprise, public service, years till end of work, career interruptions, occupational change. b = partial logistic regression coefficients (log odds). SE = clustered standard errors (by occupation). Bold: significant at 95% level.

Source: DEAS 2017.

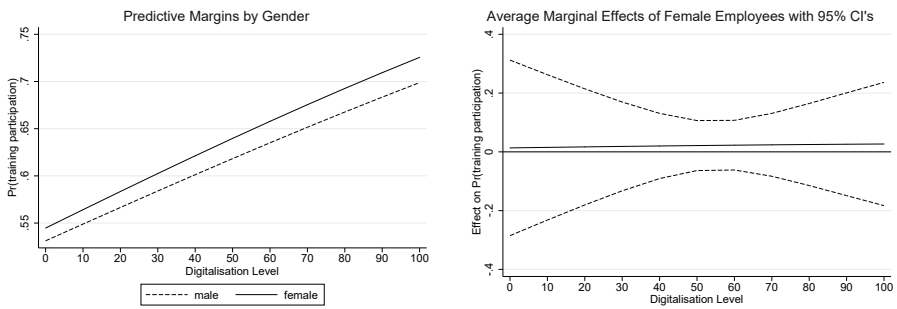
The included interaction effect of gender and digitalisation level was not significant in model 2 or in model 3, but a significant negative interaction effect of the change in the digitalisation level and gender was found in model 3 (b = -0.418; p = 0.017; SE = 0.175) (see table 2, figure 1 and 2).[16] For average female employees,

15 A model containing no control variables except the DEAS sampling variables of age and residency was estimated for employees' training participation as well as for their desire to participate in training. The model predicting training participation was not significant. The model predicting employees' desire for training indicated a positive association with the digitalisation level (b = 0.198; SE = 0.095; p = 0.037) and a negative association with age (b = -0.562; SE = 0.086; p = 0.000); a negative association for gender was found at 90% confidence level (b = -0.264; SE = 0.154; p = 0.086).

16 While the coefficient of DL is not significant, the direction is positive. For the interaction of gender and DL the coefficient is not significant and close to zero (see table 2 and 5). A larger sample could shed light on possible associations.

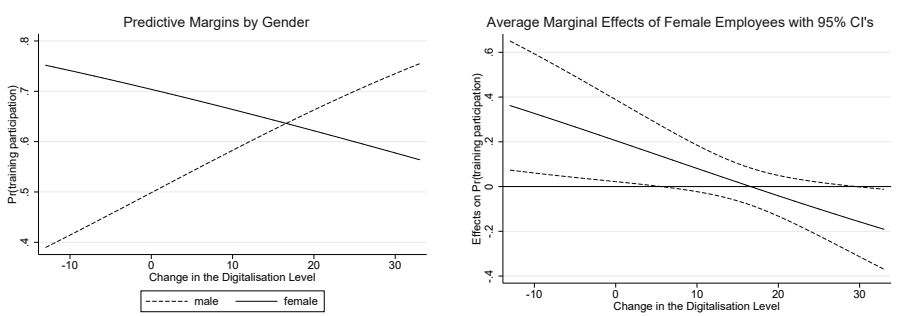
the likelihood of training participation decreased if the change in the digitalisation level increased about one standard deviation. An average woman working in an occupation that experienced a negative or low change in the digitalisation level had a higher likelihood of training participation than men; however, for high changes in the digitalisation level in occupations, women had a lower likelihood of training participation than men (see figure 2, left).[17] The more pronounced the change in the digitalisation level in occupations, the lower the likelihood of training

Figure 1: Interaction Between Digitalisation Level and Gender on Training Participation.



Source: DEAS 2017.

Figure 2: Interaction Between the Change in the Digitalisation Level and Gender on Training Participation.



Source: DEAS 2017.

17 Confidence intervals (CI) are not reported in figures 1–4 for the margins-plots on the left. The computation of CIs on predicted values for the groups of men and women would be misleading, since overlapping CIs do not necessarily imply that there are no significant differences (Cumming/ Finch 2005; Tan/ Tan 2010). As suggested in Tan and Tan (2010), the use of CIs is more intuitive if they are computed for the difference between two groups (see figure 1–4, right). Here the difference between men and women is significant if the CIs do not include the value 0.

participation for average female employees; for average male employees it increased. For the main effects of the change in the digitalisation level (b = 0.270; p = 0.038; SE = 0.130) and gender (b = 1.011; p = 0.026; SE = 0.455), positive associations with training participation were found (see table 2).

Regarding employees' desire to participate in future training, in the first model controlling for compositional effects, no significant association for the digitalisation level was found for the average male employee and no gender differences were found regarding the desire to participate in training. The added interaction terms of the digitalisation level and gender in the second and third model were also not significant (see figure 3).[18]

Table 3: Digitalisation and the Desire to Participate in Training of Employees in Their Second Half of Working Life in Germany.

	Model 1	Model 2	Model 3
Digitalisation Level	0.151	0.127	0.126
	(0.089)	(0.107)	(0.110)
Gender (ref.: male)	-0.171	-0.172	0.347
Female	(0.206)	(0.207)	(0.367)
Gender # Digitalisation Level		0.048	-0.006
		(0.170)	(0.178)
Change in Digitalisation Level			**0.383**
			(0.115)
Gender # Change in Digitalisation Level			-0.225
			(0.138)
Constant	**0.836**	**0.838**	-0.063
	(0.178)	(0.177)	(0.315)
n	1,018	1,018	1,018
Prob. > χ^2	0.000	0.000	0.000
$R^2_{Adj.\ McFadden}$	0.103	0.103	0.113
AIC	1,217.473	1,219.360	1,209.529

Note: Control variables: age; residency; education; housework; young child in same household; gender composition of occupations; working hours; small enterprise; public service; years till end of work; career interruptions; occupational change. b = partial logistic regression coefficients (log odds). SE = clustered standard errors (by occupation). Bold: significant at 95% level.

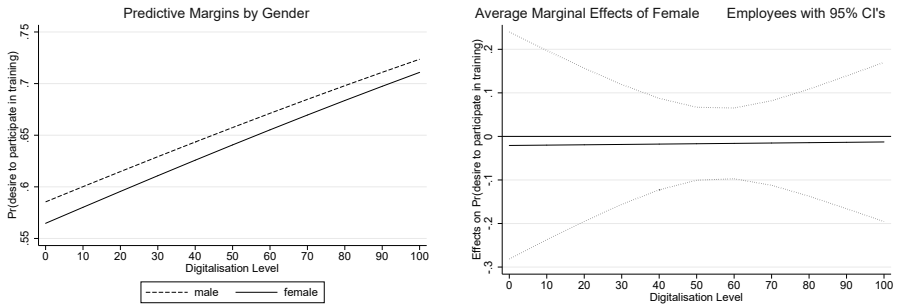
Source: DEAS 2017.

Likewise, the interaction term of the change in the digitalisation level and gender (added in the third model) and the main effect for gender were not significant (see figure 4). However, the main effect of the change in the digitalisation level was positively associated with the desire for training participation (b = 0.383; p = 0.001; SE = 0.115) (see table 3). The more pronounced the change in the digitalisation level

18 Albeit not significant, the direction of the coefficient of DL is positive, whereas the coefficients of the interaction the CDL with gender are not significant, but negative. The interaction of gender and DL is not significant and close to zero.

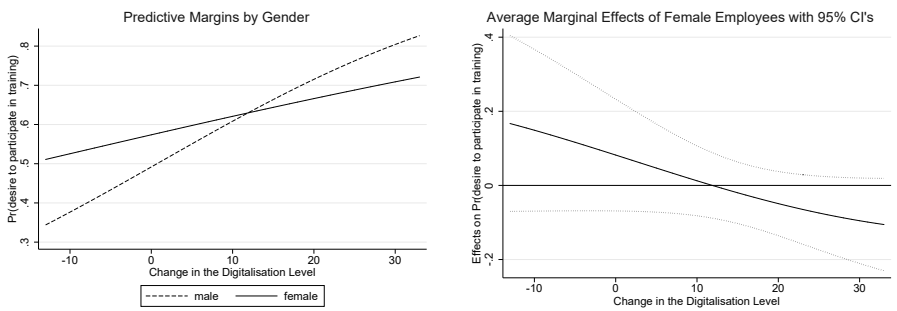
in employees' occupations, the greater the desire for male employees to participate in training. Complete results are available in table 6 in the appendix.

Figure 3: Interaction Between the Digitalisation Level and Gender on Employees' Desire to Participate in Training.



Source: DEAS 2017.

Figure 4: Interaction Between the Change in the Digitalisation Level and Gender on Employees' Desire to Participate in Training.



Source: DEAS 2017.

4 Discussion

Overall, the findings suggest that the likelihood of training participation increases for male employees if their occupations had experienced a more pronounced change in the digitalisation level over previous years. This finding for male employees is in line with hypothesis H1.a. It can be assumed that changes in the digitalisation level in occupations are associated with changing occupational requirements for employees. Training could be one measure to adapt the skills and knowledge of employees in their second half of working life to such altered requirements. However, in comparison to their male counterparts, female employees show a

decreasing likelihood of training participation if their occupation was subject to a strong increase in the digitalisation level over previous years. Furthermore, the more pronounced a change in the digitalisation level in occupations is, the greater seems the decrease in women's likelihood of participating in training to be. These findings are not in line with hypotheses H1.a and H1.b. In order to explain the lower likelihood of training participation among women working in occupations with high changes in the digitalisation level it seems not sound to draw on HCT or segregation theories, since gender differences in several aspects of time allocation, education and segregation effects in the labour market are controlled for. Gender stereotypes and role models appear to be potential explanations for the findings. Female employees might be regarded as less capable in acquiring new digital skills or their self-efficiency regarding digital competencies might be regarded as lower than that of male employees. However, conclusions have to be drawn carefully, since the reasons for non-participation in training are unknown. A higher digitalisation level was not associated with a higher likelihood of training participation, and no gender differences were found to that regard. Therefore, hypotheses H1.a and H1.b were inconsistent with the findings regarding the digitalisation level. One possible explanation is that digital skills were a criterion in hiring decisions in these occupations or that digital skills were acquired on the job.

However, in contrast to the theoretical considerations, a higher training participation was found for women in occupations that experienced a low or small change in the digitalisation level. This reversed gender training gap has also been found in some previous studies (BMBF 2021; Cedefop 2016; Jones et al. 2008). In this context it is often highlighted that the female employment rate is still considerably lower than the male employment rate, and female employees might be characterised by some factors not considered in this analysis, such as high career orientation. Furthermore, the analysis levels out differences, such as in working hours, care responsibilities, sector, or education. Since employees' desire for future training participation was also examined, some implications can be derived to explain the gender difference in relation to the change in the digitalisation level in training.

Employees working in occupations that have experienced a more pronounced change in the digitalisation level seem to be more likely to express the desire for training participation. For the digitalisation level, no significant effect was found. Therefore, the findings are consistent with hypothesis H2.a with regard to the change in the digitalisation level, but not the digitalisation level. Employees' willingness to participate in training might be higher in occupations with more pronounced changes in the digitalisation level since they might have experienced a skill mismatch. In addition, transformation processes in occupations due to digitalisation may especially affect older employees, since their initial vocational education or training is likely to be longer ago than that of younger employees, and skill mismatches have had more time to grow. The findings do not reveal gender differences in the desire to participate in training, nor in relation to the

digitalisation level or change in the digitalisation level. Therefore, the findings are inconsistent with H2.b. These findings, along with the findings on gender differences in training participation, allow for different explanations. They may indicate that employers disadvantage women working in occupations that have experienced a strong increase in the demand for digital skills. Another possible explanation is that women desire to participate in training in general but are not appealed by existing training offers.[19]

As it is usual, also this study comes with some potential limitations that have to be mentioned. Unfortunately, it was not possible to control for whether training was financed by the employer, the state, the employee, or by a mixed source. The financing source, however, has been found to differ systematically among the genders. While women are found to be more likely than men or equally likely to participate in training that is not financed by the employer (self-financed or state-financed), they are less likely to participate in employer-financed training (Aisa et al. 2016; Dämmrich et al. 2016). Nonetheless, it can be assumed that the majority of job-related training was employer-funded, as statistics for Germany suggest (Cedefop 2016). In addition, the data provides no information on potentially relevant control variables, such as the employment contract or the employees' career orientation. Furthermore, the data contains no information on the training context and content. This means that it is not possible to conclude that training courses or seminars were focused on improvement or provision of employees with digital skills. Also, the data contains no information on the training length or if it took place during working time. This could affect men and women differently. Lastly, a conceptual shortcoming should be mentioned. Since the digitalisation measures used in the analyses are determined on occupational level, they do not account for within-occupation heterogeneity regarding the demand for digital skills (for a general discussion on this issue see: Autor/Handel 2013; Avent-Holt et al. 2020; Cassidy 2017; Christoph et al. 2020). Even while working in similar occupations, female and male employees may show systematic differences in what they actually do in their jobs (Martin-Caughey 2021). Job-level data could offset these shortcomings accounting for within-occupation heterogeneity. Data that offers fine-grained insights into the task content of individuals' jobs are PIAAC data (OECD) or the BIBB/BAuA employment survey (Germany). Since skill demands are closely related to job tasks, such data could be used in future studies. However, deriving work tasks respectively skill demands from occupations is likewise assessed as valuable approach for two reasons: 1) Information derived from occupations is easily avail-

19 In an additional analysis, model 3 assessing the likelihood of training participation was re-estimated adding a control variable depicting the employees' desire to participate in future training expressed in 2014 (see table 10 in the appendix). The findings reveal a significant and substantial positive association of the employees' desire to participate in future training with the likelihood of training participation. The coefficients of all other variables showed patterns comparable to those in the analyses presented above.

able and usually of high quality. 2) Occupations provide high explanatory power for individual-level differences (Autor/ Handel 2013; Mouw/ Kalleberg 2010; Williams/ Bol 2018). An important characteristic of the data on digitalization used in the analyses is, that they are based on online job advertisements. This is linked to some drawbacks that are discussed more in detail in works from Carnevale et al. (2014), Cedefop (2021), O'Kane et al. (2020). Data from job advertisements rather depict future skill demands for open positions that do not necessarily match skill demands that employees actually face. However, this slightly forward-looking demand perspective in the digitalization data is not necessarily inappropriate for analyses on job-related training. Lastly, the number of employees for occupations in the lowest and highest marginal areas of the digitalisation level and the change in the digitalisation level is rather low. A larger sample could further substantiate our results. Nevertheless, robustness checks that are presented in the appendix are confirming the findings of the main analysis (see table 11 and 12 in the appendix).

5 Conclusion

In summary, three conclusions can be derived. First, it is important to differentiate between the digitalisation level of occupations and the extent of the change in the digitalisation level that occupations experience over a given time period. Both measures depict digitalisation in a broader sense but focus on different aspects of digitalisation. Second, a pronounced change in the digitalisation level in occupations is associated with a higher likelihood of training participation in their second half of working life for men than women, and an increase in the desire for training participation for both men and women. The digitalisation level of occupations is neither associated with the likelihood of training participation nor with the likelihood of the desire for training participation. One explanation might be that digital competencies are a job requirement for occupations with a high digitalisation level and need not be refreshed or acquired by additional training of employees in their second half of working life. In contrast, an average older employee working in an occupation that has experienced a pronounced change in the digitalisation level might face greater skill mismatches in their job. Entrance requirements today might differ considerably from entrance requirements experienced by older employees. Third, the likelihood of training participation decreases more for female employees the more pronounced the change in the digitalisation level in the occupation they are working in. For male employees it increases. Along with the finding that there are no gender differences in the desire to participate in training, the findings suggest that employers might disadvantage women in the provision of suitable training opportunities in occupations that have experienced a pronounced change in the digitalisation level, or that female employees feel less compelled to take up existing training offers in such occupations or assess them as not suitable for themselves.

In sum, future research on digitalisation in work should distinguish between the digitalisation level and the change in the digitalisation level in occupations, as both aspects of digitalisation have different implications. Furthermore, while training is often discussed as a key measure for changing skill requirements, it is important to be aware of potential differences in the access to and participation in training. The Federal Government has formulated the goal of "shaping digitali[s]ation" in order to make the potentials of digitisation accessible to all population groups and avoid an exacerbation of social inequalities. At the same time, equality between men and women is demanded by law (Art. 3 para. 3 GG). In view of the revealed gender differences, public and operational training measures and strategies must aim to offset this imbalance. Increased awareness of this imbalance, as well as a reduction in gender stereotypes regarding digital competencies, could mitigate the digitalisation-gender gap in training participation. Training offers for digital competencies that explicitly address women could lower barriers for training participation among female employees. In addition, state legislation should (further) encourage gender-sensitive training offers from employers through financial support that is only granted if employers' training offers are linked to gender equality goals.

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