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Regional differences in digitalisation and their impact on young people's status attainment in vocational education and training

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ABSTRACT

While many of the recent changes in the labour market are related to digitalisation, there is little knowledge about digitalisation's impact on young people's transitions from school to vocational education and training (VET). The current study addresses this research gap by examining the relationship between the level of regional digitalisation and young people's status attainment when entering VET. The study uses data from the German National Educational Panel Study (NEPS), merged with a unique regional digitalisation indicator at the district level (NUTS-3). OLS regression models show that, on average, young people entering VET in highly digitalised regions secure occupations with a higher status than their counterparts in less digitalised regions. Notably, regional digitalisation has a particularly strong positive impact on males, while no differences in association are observed by school leaving qualifications. The results underscore the existence of a discernible regional digital divide among VET entrants in Germany.

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Digitalisation; educational qualification; gender; regional differences; status attainment; VET

Introduction

Technological and digital change has led to fundamental structural changes in the labour market, bringing new opportunities as well as challenges, such as the polarisation of employment and wages (Acemoglu 1998; Acemoglu and Restrepo 2020; Frey and Osborne 2017; Gil-Hernández, Vidal, and Torrejón Perez 2023; Kristal 2013; Martinaitis, Christenko, and Antanavičius 2021). There is some empirical evidence to suggest that digitalisation processes are associated with an increasing demand for highly skilled workers, especially in work fields where machines and computers are frequently used

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(Black and Spitz-Oener 2010; Freddi 2018). However, while previous studies focus on the national or occupational level, little is known about the impact of digitalisation on micro-level outcomes, including young people's status attainment in the vocational education and training (VET) system. The group of young people entering VET is of particular concern, not only in terms of ensuring a highly skilled workforce, but also because the early transition to VET sets the course for the rest of young people's working life.

Time trend studies at the country level have provided some broad insights into general labour market trends, such as the tendency towards the demand for higher skills in many European countries (Martinaitis, Christenko, and Antanavičius 2021; Oesch and Piccitto 2019; Oesch and Rodríguez Menés 2011; Pusterla and Renold 2022). These studies, however, have the disadvantage of neglecting regional differences within countries, which makes it difficult to identify labour market structures related to digitalisation. Given the heterogeneity of regions, it can be assumed that digitalisation is not occurring at the same pace everywhere, but that societal and regional structures and barriers shape its spread. Although previous research has pointed to the crucial role of local labour market conditions for the transition from school to VET (Eckelt and Schauer 2019; Hartung, Wessling, and Hillmert 2019; Malin and Jacob 2019; Wicht et al. 2024), the relevance of regional differences in digitalisation has so far been largely neglected. In the German labour market, however, region-specific digitalisation could be particularly relevant for the prevalence of higher-status VET occupations, as firm-based (dual) training is widespread and companies are embedded in local structures (Kleinert, Vosseler, and Blien 2018). Thus, in addition to the established research on the relevance of local labour market characteristics, such as unemployment, for the transition from school to VET, it is worth investigating whether digitalisation is a driver of young people's status attainment within the VET system at the small-scale regional level.

Taking the perspective of skill-biased technological change (Acemoglu 1998) and regionally structured social inequalities (Kleinert 2015), our study addresses the question of (1) whether regional disparities in digitalisation are associated with the status attainment of young people in transition to VET in Germany. In light of the highly standardised and stratified education and training system (Allmendinger 1989; Protsch and Solga 2016) as well as the high horizontal gender segregation in the German labour and training market (Charles and Grusky 2005; Kleinert and Schels 2020), we also explore (2) heterogeneous correlations between regional digitalisation and status attainment by educational qualification and gender. We use large-scale longitudinal data from the National Educational Panel Study (NEPS) to draw on the status attainment of young German school leavers entering their first fully qualifying vocational training. These data are linked with a newly developed measure of regional digitalisation at the level of NUTS-3 regions (Detemple and

Wicht 2024), which combines various facets of digitalisation in a comprehensive measurement. The integration of individual and regional data allows for a differentiated analysis of whether and for whom digitalisation represents a fault line of social inequality in the transition from school to VET.

Theoretical background and previous research

Changing labour and training markets due to digitalisation

The theoretical basis for much of the research on the impact of digitalisation on labour markets and society stems from the theory of skill-biased technological change (Acemoglu 1998, 2002), which assumes that one important consequence of technological advances since the mid-20th century has been upskilling and an increasing demand for high-skilled workers (Acemoglu 2002). The argument is that new technologies are complementary to higher-skilled workers, who in turn raise their relative productivity, meaning that companies derive greater benefits from these workers. As a consequence, digitalisation can also be associated with an increasing demand for higher-status occupations, as occupations with higher skill requirements tend to be better paid and have a higher socio-economic status (Ganzeboom 2010).

The theory of skill-biased technological change has been tested empirically for different countries using a variety of indicators for automation, innovation or digitalisation (Acemoglu and Restrepo 2020; Frey and Osborne 2017), showing that technological change leads to structural change in the labour market. Evidence of skill-biased technological change in countries with a strong VET system, such as Germany or Switzerland, is supported by several studies. For instance, Bellmann and Schank (2000) demonstrate that the positive impact of innovation on labour demand rises with skill level. Kölling and Schank (2002) find that investment in information and communication technologies (ICT) increases the demand for both medium and highly skilled workers. Similarly, Pusterla and Renold (2022) show that ICT has an upskilling effect on the educational composition of a workforce. Furthermore, Oesch and Rodríguez Menés (2011) and Spitz-Oener (2006) show that digitalisation and technological change lead both to a growing supply of high-skill occupations and to rising skill requirements within occupations.

Compared to general links between digitalisation and labour markets at the macro level, the specific impact of digitalisation on individual outcomes, including young people's access to VET, is less clear. Considering that digitalisation changes the distribution and the task content of jobs and leads to upskilling, it

can be assumed that it also influences the VET system and the kind of occupational training demanded of it.

Regional differences in digitalisation and the status attainment of young people

According to rational choice theories (e.g. Boudon 1980), young people self-select into occupations that maximise their utility, taking into account outside factors such as availability and accessibility, and considering individual (subjective) cost-benefit analyses. Unlike what most theoretical models assume, young people do not enter a national, homogenous labour market but rather find themselves facing very heterogeneous local labour market conditions that tend to be persistent over time (Abbott 1997; Blien 2001; Hillmert, Hartung, and Weßling 2017; Kleinert, Vosseler, and Blien 2018). Furthermore, regional heterogeneity has been also identified for certain digitalisation indicators, such as the spread of website domains (Sternberg and Krymalowski 2002; Wicht, Stephen, and Clemens 2021), the availability of broadband connections (Clercq, Haese, and Buysse 2023) and the potential for job automation (Kropp and Dengler 2019).

Moreover, regional opportunity structures, such as the general economic situation of a region or the dominant economic sectors of local firms and their occupational structure, which determine the supply of VET positions, have consistently been shown to play an important role in influencing young people's occupational opportunities in the VET market (Heineck, Kleinert, and Vosseler 2011; Hillmert, Hartung, and Weßling 2017; Meyer and Winkler 2023; Schmidt and Uhly 2023; Ulrich 2013; Wicht and Nonnenmacher 2017; Wicht et al. 2024) as well as their occupational expectations and choices (Flohr, Menze, and Protsch 2020; Hartung, Weßling, and Hillmert 2022; Malin and Jacob 2019). And yet little is known about the impact of regional digitalisation. Based on the argument that digitalisation increases the demand for higher-status occupations, we assume that young people in regions with a higher level of digitalisation will take up higher-status VET occupations compared to their counterparts in less digitalised regions (Hypothesis 1).

The role of school-leaving qualifications in the association between regional digitalisation and status attainment in VET

Traditionally, VET has been open for young people with all kinds of school-leaving qualifications. However, higher qualifications as a signal of productivity or trainability are important for access chances (Spence 1973), and the dynamics of educational expansion have led to an increase in VET entrants with higher educational qualifications (Beicht and Walden 2018; Protsch and Solga 2016). At

the same time, the labour demand in occupations more affected by digitalisation has also increased, as shown by the rise of employment in ICT (Acemoglu 1998; Destatis 2023).

Following job competition theory (Thurow 1975), education is not an absolute, but a relative good. The allocation of workers to jobs depends mainly on two factors: the anticipated training costs given the applicant's educational qualifications, and the quality of their competitors. Employers fill vacancies along a labour queue ranked by the qualifications of applicants in order to minimise anticipated training costs. In the event of an increased demand for high-skilled labour, employers are forced to hire potentially more expensive candidates further back in the queue in order to fill vacancies. Therefore, in regions with a high level of digitalisation, the growing supply of high-skilled occupations and VET positions could force companies to adapt their hiring practices towards also recruiting people with lower educational qualifications.

In Germany, with only slight differences between the federal states (*Länder*), children are generally sorted into one of three different hierarchical school tracks after year four or six (at the age of approximately ten or twelve, respectively), which allow school leavers to obtain three different, hierarchically ordered degrees (Protsch and Solga 2016). The first track provides a lower secondary school degree (*Hauptschulabschluss*) after year nine or ten, and the second track provides an intermediate secondary school degree (*Realschulabschluss*) after year ten. These degrees traditionally prepare school leavers for a career in VET and do not allow them to immediately pursue tertiary education. The third track provides school leavers an upper secondary school degree (*IFach-JAbitur*) after year twelve or thirteen and serves as a university entrance qualification.

Despite early tracking, the German education system does allow for some upward mobility. Students can continue their education after completing the first or second school track if they meet the necessary academic requirements. Conversely, students from the third track who drop out after year nine or ten receive a lower or intermediate degree, respectively. With more young people leaving school with university entrance qualifications than in the past, the share of higher educated school leavers in the VET system has also increased in recent decades (BIBB 2019). Following Protsch and Solga (2016), we translate the German school degrees into lower, intermediate and upper secondary school leaving qualifications.

Despite the lack of formal entry qualifications for many VET occupations, there is quite extensive segregation in the access to the German VET system (Protsch and Solga 2016; Schels and Abraham 2023), i.e. many occupations are traditionally filled by school leavers with a certain educational qualification (Beicht and Walden 2018). Most young people entering dual VET occupations have at least an intermediate secondary school leaving qualification; in school-based VET this number is even higher

(Protsch and Solga 2016). School leavers with at most a lower secondary school leaving qualification often enter pre-vocational training before enrolling in a VET programme. The German VET system is therefore no less stratified than the German school system, and its stratification heavily depends on general school leaving qualifications. However, the relationship between educational qualification and the prospect of a VET position varies according to regional competition for VET positions (Eckelt and Schauer 2019).

Young people with upper secondary school leaving qualifications who are motivated to enter the VET system can be assumed to strive for higher-status VET occupations regardless of the regional context. As digitalisation should increase the number of higher-status VET occupations, we assume its impact to be more pronounced for young people who do not have an upper secondary school leaving qualification (Hypothesis 2).

Gender segregation in the association between regional digitalisation and status attainment

The German labour market is characterised by a high degree of horizontal gender segregation rooted in gender-typical career aspirations and choices among young people (Kleinert and Schels 2020; Wicht and Siembab 2022), as is the case in many other advanced industrialised countries (Charles and Bradley 2009; Charles and Grusky 2005). Significant gender segregation is also evident in Germany's VET market. Technical, company-based occupations that heavily employ computers and digital technology and are more susceptible to digitalisation (Black and Spitz-Oener 2010; Freddi 2018) are typically male-dominated. Conversely, full-time school-based occupations are primarily pursued by women (Beicht and Walden 2014; Jacob, Kleinert, and Kühhirt 2013; Thébaud and Charles 2018). For instance, occupations associated with information and communications technologies had a 91% share of male apprentices in 2021; in occupations in the field of mechatronics and automotive technologies these shares were up to 98% (BIBB 2022).

Theoretical approaches from social psychology have been widely used to explain this persisting degree of horizontal gender segregation (Eccles 1987, 1994; Gottfredson 1981). Young people's occupational aspirations and choices are formed by cultural norms about gender roles in society, as well as their subjective perception of viable options (Eccles 1994). In interactions with significant others while growing up, children internalise gender-specific ideas about which occupations are appropriate and potentially interesting for their own gender (Gottfredson 1981). This is in line with research on gender-specific interest profiles (Holland 1992), which has shown that girls lean towards social and artistic tasks, while boys show greater interest in scientific, technical and mechanical tasks (Betz

and Fitzgerald 1987; Su, Rounds, and Ian Armstrong 2009; Wicht, Miyamoto, and Lechner 2022). In addition, women who aspire to and are qualified for a technical occupation may face rejecting behaviours due to gender stereotypes (Devine 1992) or fear discrimination in male-dominated occupations and therefore not consider them as viable career options (Eccles 1994).

Based on the empirical evidence on horizontal gender segregation and the theoretical expectation that digitalisation has a greater impact on male-dominated technical occupations, we assume that the impact of digitalisation is stronger for men's status attainment in VET (Hypothesis 3).

Data and methods

Data

Our study used large-scale representative data on youths' status attainment associated with their first fully qualifying VET position from starting cohorts 3 (SC3) and 4 (SC4) (NEPS Network (2024a), 2024b) of the National Educational Panel Study (NEPS; Blossfeld and Roßbach 2019). The initial sample consisted of 24,742 individuals (SC3: $N=8,317$; SC4: $N=16,425$) attending regular secondary schools in Germany. Interviews for both starting cohorts were first conducted in the fall of 2010 and repeated at least annually until 2021. Whereas SC3 initially started with students in year five, SC4 focused on year nine students. Since students in Germany usually leave secondary school either after year nine, ten, twelve or thirteen (depending on the educational qualification they pursue, see the theory section for more details), the students in SC3 finished school in the same age range but a few years after those in SC4. The same types of questions were asked at the respective time points in both starting cohorts. Because of the long observation period, both starting cohorts offered rich and detailed longitudinal data on young people's secondary schooling and postsecondary transitions. One of the strengths of NEPS lies in the possibility of merging small-scale regional data at the level of German districts (NUTS-3). For our analyses, we used information on the district of the attained VET position.

The sample was restricted to young people whose school and VET district information was available, who had no gaps longer than six months without valid information and who participated in a VET programme for at least three months within the first two years after their secondary schooling. The analysis sample included 8,027 individuals covering school-leaving cohorts from 2010 to 2019. The data preparation was partly based on the replication code of Hoffmann and Wicht (2023b).

Table 1. Descriptive statistics of the non-imputed and unstandardised variables.

	Mean	S.D.	Min	Max	N	% Missing
Status attainment	39.34	13.63	11.56	84.14	7,866	2.01
Regional digitalisation	0.46	1.10	−0.50	3.76	8,027	-
Educational qualification					7,986	0.51
– upper secondary degree	0.23	-	0.00	1.00		
– intermediate secondary degree	0.50	-	0.00	1.00		
– lower secondary/no degree	0.27	-	0.00	1.00		
Gender, ref.: male	0.46	-	0.00	1.00	8,027	-
Migration background, ref. native	0.22	-	0.00	1.00	7,893	1.67
Rural, ref. urban	0.36	-	0.00	1.00	8,027	-
Parental socioeconomic status	49.68	19.54	11.74	88.96	6,947	13.45
No. of books in the home	3.70	1.44	1.00	6.00	7,610	5.19
Starting cohort, ref. 4	0.25	-	0.00	1.00	8,027	-
Mobility, ref. first VET in the same region as general schooling	0.39	-	0.00	1.00	8,027	-
Age after general schooling	18.43	1.30	14.00	23.00	7,974	0.66

Source: NEPS, Starting Cohort Grade 5 (doi:10.5157/NEPS:SC3:13.0.0), and Starting Cohort Grade 9 (doi:10.5157/NEPS:SC4:14.0.0); Detemple and Wicht (2024). Authors' calculations.

Variables

In the following, we describe the relevant measures of the variables used in the study. Table 1 gives an overview of the basic descriptive statistics of the theoretically important variables of status attainment, regional digitalisation, educational qualification and gender, as well as the variables used as controls. Differences in the variable distributions between urban and rural regions and between areas of Germany (northern, eastern, southern and central) are provided in the Supplemental Material (see Tables A1 and A2).

Status attainment. We used the International Socio-Economic Index (ISEI-08; Ganzeboom 2010) to measure the socioeconomic status of the VET position attained, which is the dependent variable. The ISEI was developed and validated based on the International Social Survey Programme (ISSP) and is a well-established objective measure of occupational stratification based on information about required educational qualifications and expected income (Ganzeboom 2010). However, it is important to acknowledge that some aspects of the index may not fully align with the specific characteristics of the German labour market, reflecting a common challenge with international scales. The NEPS assigned ISEI scores to the occupations reported by students based on the International Standard Classification of Occupations (ISCO-08; International Labour Office 2012). The original ISEI scale ranges from 11.01 (arable farmers/livestock keepers) to 88.96 (judges). In our sample of VET entrants, the ISEI scale ranges from 11.56 (field crop and vegetable growers) to 84.14 (veterinarians). For a comprehensive overview of all occupations in the sample, along with corresponding examples of German VET occupations and their respective ISEI values, see Table A3 in the Supplemental Material.

Regional digitalisation. We used a measurement developed by Detemple and Wicht (2024) that combines several regional indicators from administrative data sources at the level of German districts (NUTS-3) to measure digitalisation as a latent construct (McDonald's Omega 0.78, RMSEA = 0.04, CFI = 0.99 and SRMR = 0.03). We used the earliest available version from 2013. As regional differences in the digitalisation measurement remain stable over time (Detemple and Wicht 2024), we do not account for changes over time.

Figure 1 shows the distribution of the digitalisation factor across German regions for 2013. A large degree of regional variance can be observed across the country. Urban districts (roughly indicated by smaller district sizes) tend to have higher levels of digitalisation. Moreover, the distribution is skewed to the right, suggesting that most regions have some basic level of digitalisation. The regions with the highest levels of digitalisation are Munich (both the city and the county district), Frankfurt and Düsseldorf (Detemple and Wicht 2024).

Consistency checks revealed a non-linear relationship between status attainment and regional digitalisation; we tested various strategies to address this. Based on the goodness of fit model (Bayesian Information Criterion, BIC), the model with a truncated digitalisation factor performed better than models with a quadratic factor or the original factor and was also superior to using percentiles. The best solution was achieved by truncating the digitalisation factor at the empirically determined threshold of -0.5 through bottom coding.

Educational qualification. The highest school leaving qualification attained before entering VET was used, distinguishing between (1) lower secondary (*Hauptschulabschluss*) or no degree, (2) intermediate secondary degree (*Realschulabschluss*) and (3) upper secondary degree (*[Fach-]Abitur*, equivalent to a university entrance qualification).

Gender. This variable distinguished between the two major gender groups, female and male students (reference category). No other category was given to measure gender.

Immigration. Youths with a migration background include those who immigrated to Germany themselves and those who have at least one parent who immigrated to Germany. Youths without a migration background form the reference group.

Parental socioeconomic status. As for youths' status attainment, this variable was measured by the highest ISEI-08 associated with parental occupation.

No. of books. The number of books available in the home is the most frequently used measure of cultural capital (see e.g. Heppt, Olczyk, and Volodina 2022; Sieben and Lechner 2019, for validations). The scale ranged from 1 (none or only very few books) to 6 (enough to fill a shelf unit); the questionnaire used visual illustrations to support students' assessments of the number of books in their homes.

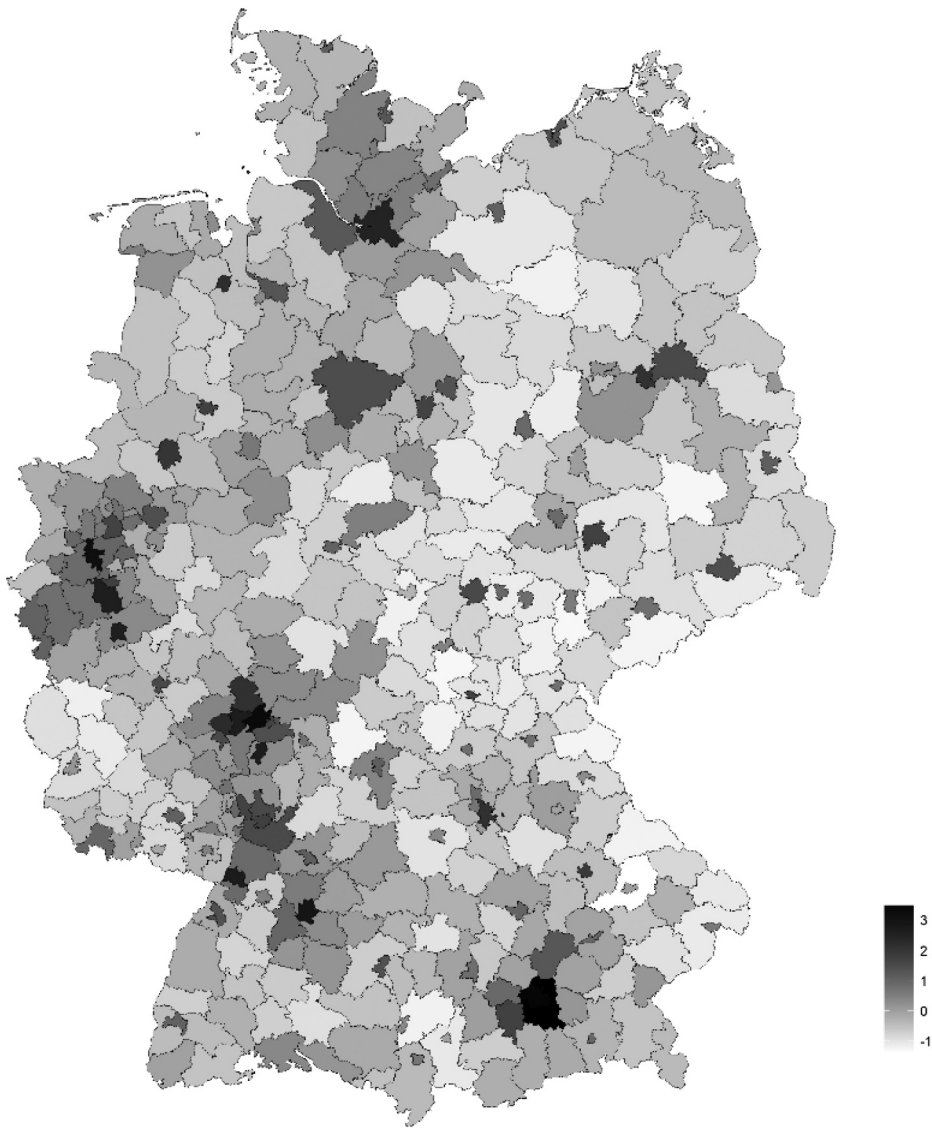


Figure 1. Digitalisation factor across regions in Germany for the year 2013.

Source: Detemple and Wicht (2024). © GeoBasis-DE/BKG, 2023.

Starting cohort. We used an indicator for the NEPS starting cohort to account for systematic differences between the survey participants in starting cohorts 3 and 4 (reference category).

Agglomeration/Urbanity. Rural and urban areas were operationalised based on a typology by the Federal Office for Building and Regional Planning that distinguishes between large independent cities and urban districts on the one hand, and rural and sparsely populated districts on the other (BBSR 2013). Urban areas form the reference category.

Spatial mobility. This indicator identifies whether students' VET position was in the same district as their secondary school (reference category) or a different one.

Analytical strategy

Ordinary least squares (OLS) regression was used to predict the attained status of young people entering their first VET. Models were implemented for all regions, as well as separately for urban and rural regions to better disentangle the relevance of digitalisation for status attainment depending on agglomeration/urbanity. To test for subgroup differences in the association under study, interaction terms between regional digitalisation and young people's educational qualification and gender were included in further analyses. Migration background, parental socioeconomic status, number of books in the home, spatial mobility for the first VET position and starting cohort membership were considered as control variables to account for processes of systematic self-selection of young people and their parents into regions with different degrees of digitalisation. For better comparability of effect sizes, all continuous independent variables were z-standardised. The regression parameters thus expressed changes in status attainment by standard deviations for these variables.

To account for serial correlations between young people in larger regional contexts, cluster-robust standard errors were used at the level of labour market regions (Kosfeld and Werner 2012). In order to deal with missing values in the dependent and independent variables, we used a two-level multiple imputation procedure with random intercepts to create 30 imputations using Blimp 3.1 (Enders, Keller, and Levy 2018), which accounted for the multilevel structure of the data. We carried out separate imputations for the urban and rural area subsamples. The imputation model included all variables used in the analysis models. To ensure transparency, we also conducted our main analyses using non-imputed data (see Supplemental Material; Tables A4–A6).

The analysis code was uploaded to a publicly accessible registry system and can be accessed via <https://doi.org/10.7802/2853>

Results

Is region-specific digitalisation positively associated with the status attainment of young people in their transition to VET?

Table 2 shows the results of the association between regional digitalisation and status attainment of the first VET for the total sample as well as separately for urban and rural regions. Overall, regional digitalisation was positively correlated with the status attainment of young people: those entering VET in regions with

Table 2. Linear regression predicting status attainment of the first VET.

	All		Urban		Rural	
	β	S.E.	β	S.E.	β	S.E.
Focal associations						
Digitalisation (std.)	1.41***	[0.16]	1.41***	[0.18]	1.57*	[0.75]
Educational qualification, ref. upper secondary degree						
– intermediate secondary degree	–4.70***	[0.37]	–4.63***	[0.41]	–4.86***	[0.70]
– lower secondary/no degree	–11.80***	[0.41]	–11.84***	[0.50]	–11.77***	[0.69]
Gender, ref. male	6.49***	[0.34]	6.39***	[0.44]	6.66***	[0.55]
Control variables						
Immigration, ref. native Germans	0.30	[0.31]	0.36	[0.38]	0.15	[0.52]
Parental SES (std.)	0.84***	[0.15]	0.88***	[0.22]	0.76**	[0.24]
No. of books in the home (std.)	0.43**	[0.15]	0.45*	[0.22]	0.39	[0.24]
Mobility, ref. first VET in the same region as general schooling	0.92**	[0.34]	0.71	[0.44]	1.31*	[0.53]
NEPS SC, ref. SC4	0.02	[0.40]	0.03	[0.48]	–0.00	[0.64]
Constant	41.01***	[0.42]	41.10***	[0.53]	41.00***	[0.85]
N(persons)	8027		5161		2866	
Max. FMI	0.15		0.10		0.16	
Avg. RVI	0.05		0.04		0.05	

Notes: + $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Standard errors in brackets. Cluster robust S.E., N (regional labour markets) 139, 30 imputations. All metric independent variables are z-standardised based on the entire sample. Source: NEPS, Starting Cohort Grade 5 (doi:10.5157/NEPS:SC3:13.0.0), and Starting Cohort Grade 9 (doi:10.5157/NEPS:SC4:14.0.0); Detemple and Wicht (2024); Federal Institute for Research on Building, Urban Affairs and Spatial Development (BBSR). Authors' calculations.

a one standard deviation higher level of digitalisation had, on average, 1.41 points higher status attainment on the ISEI scale ($\beta = 1.41$; $p < 0.001$). Given the reduced variation in ISEI values among VET students compared to all workers, the correlation is notable.

Looking at the full sample may hide differences between urban and rural areas. However, the association between regional digitalisation and status attainment was similarly evident for VET entrants in urban and rural regions ($\beta = 1.41$; $p < 0.001$ and $\beta = 1.57$; $p < 0.05$, respectively) compared to the total sample. The statistical significance of the association was slightly reduced to the five per cent level for VET entrants in rural regions, which may be due to less dispersed digitalisation in rural regions and the smaller sample size. Notably, the results suggest that the relationship between digitalisation and access to higher-status VET occupations is not solely a function of urbanity. Overall, the findings confirm Hypothesis 1, that status attainment is higher in regions with a higher level of digitalisation.

Does the association between digitalisation and status attainment differ according to educational qualification?

Figure 2 shows the predicted correlations between regional digitalisation and status attainment by educational qualification for urban (left) and rural (right) regions separately. The full regression results can be found in Table A7 in the Supplemental Material.

Regional digitalisation was crucial in young people's status attainment across all educational qualifications, with pronounced differences in attainment levels persisting despite higher levels of digitalisation (see Figure 2). In urban regions, the association between regional digitalisation and status attainment was somewhat stronger for VET entrants with intermediate and upper secondary school-leaving qualifications than for those with lower secondary educational qualifications. However, these differences in slopes were not statistically significant (see Supplemental Material Table A7). Similar patterns were observed in rural regions, albeit with a much higher level of uncertainty as indicated by the broad confidence intervals. Thus, our results do not support Hypothesis 2, as

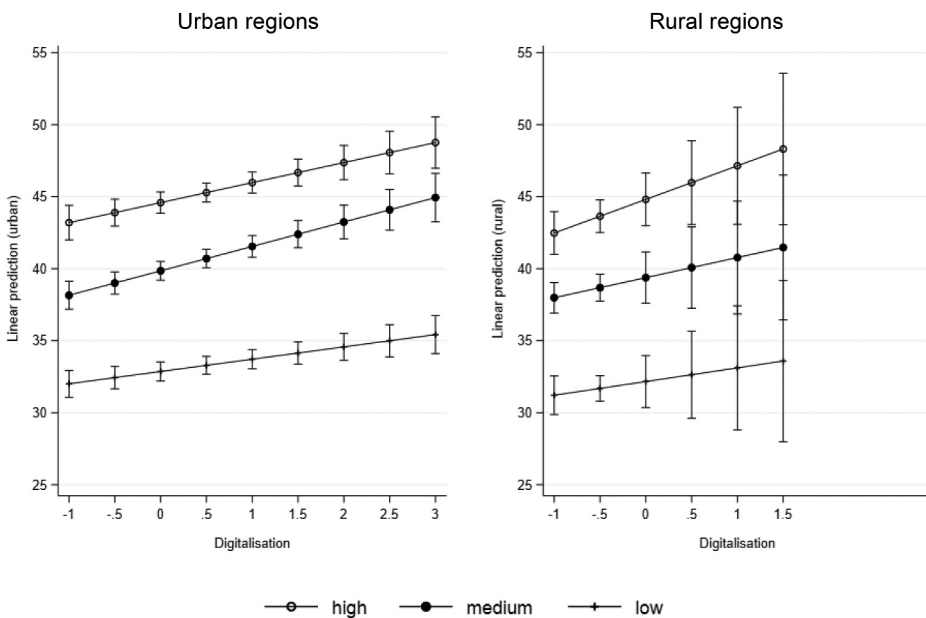


Figure 2. Differences in the associations between youths' status attainment and regional digitalisation by educational qualification in urban and rural regions.

Notes: Educational qualifications are defined as follows: lower secondary degree or no degree ('lower/none'), intermediate secondary degree ('intermediate') and upper secondary degree ('upper'). Digitalisation is z-standardised based on the entire sample. *Source:* NEPS, Starting Cohort Grade 5 (doi:10.5157/NEPS:SC3:13.0.0), and Starting Cohort Grade 9 (doi:10.5157/NEPS:SC4:14.0.0); Detemple and Wicht (2024); Federal Institute for Research on Building, Urban Affairs and Spatial Development (BBSR). Authors' calculations.

regional digitalisation benefits all VET entrants, regardless of their educational qualifications.

Does the association between digitalisation and status attainment differ according to gender?

Figure 3 shows the results for the relationship between regional digitalisation and status attainment by gender separately for urban (left) and rural (right) regions (for more detailed results, see Supplemental Material, Table A8).

The results indicate that women attained higher occupational status in VET than men and that their status attainment was only slightly affected by regional digitalisation, a pattern that could be observed in rural and urban regions. By contrast, for men living in urban regions, increasing regional digitalisation was accompanied by rising status attainment. In urban regions with a high level of digitalisation, men were therefore more likely to reduce the gender gap in status attainment. While the observed pattern was similar in rural regions, this catch-up effect was smaller and statistically insignificant. Thus, only the results for urban regions were consistent with Hypothesis 3.

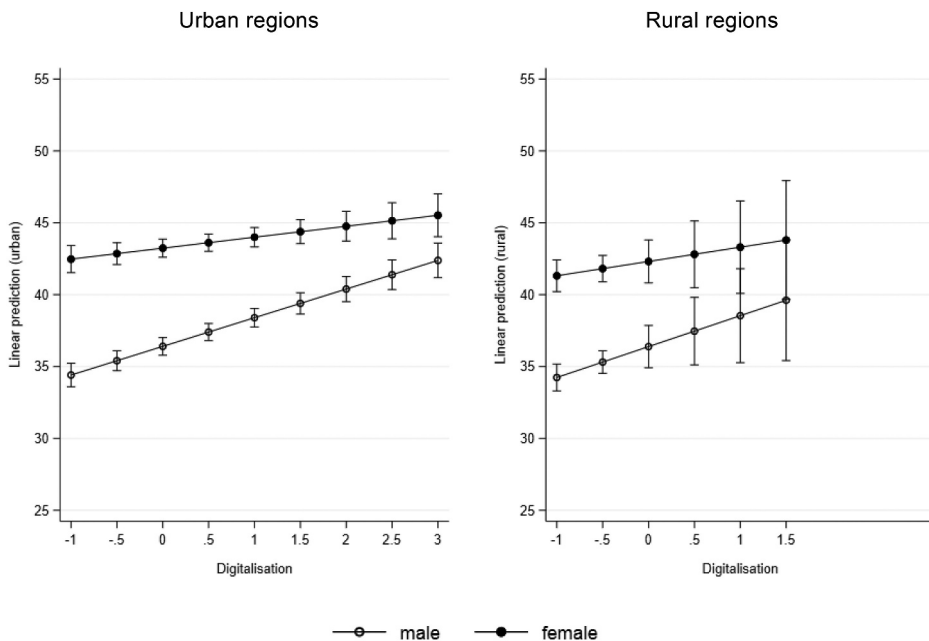


Figure 3. Differences in the association between youths' status attainment and regional digitalisation by gender in urban and rural regions.

Notes: Digitalisation is z-standardised based on the entire sample. *Source:* NEPS, Starting Cohort Grade 5 (doi:10.5157/NEPS:SC3:13.0.0), and Starting Cohort Grade 9 (doi:10.5157/NEPS:SC4:14.0.0); Wicht et al. (2024); Federal Institute for Research on Building, Urban Affairs and Spatial Development (BBSR). Authors' calculations.

Robustness checks

In order to test the robustness of the results, we computed the main model separately for northern, eastern, southern and central areas of Germany (Frick and Goebel 2008). The positive association between regional digitalisation and status attainment remained robust across areas, although its strength varied between $\beta = 1.21$ ($p < 0.001$) in southern regions and $\beta = 2.06$ ($p < 0.001$) in northern regions (see Supplemental Material, Table A9). To determine whether the results were mainly driven by cities, the same regressions were conducted including a control for urbanity. This adjustment increased the coefficients in all subsamples except for northern regions. The level of significance remained high ($p < 0.001$), except for the eastern regions ($p < 0.1$).

We conducted additional analyses to examine the reciprocal relationship between a region's level of digitalisation and its occupational structure, as reflected by the prevalence of occupational sectors, categorising occupations into five broad groups based on similarities in tasks and skill requirements (Matthes, Meinken, and Neuhauser 2015). Descriptively, VET entrants in highly digitalised regions (top third) were less likely to enter production occupations (27%) and more likely to enter different kinds of service occupations (e.g. personal: 35%, IT and scientific: six per cent), compared to those in less digitalised regions (bottom third), where 41% were in production occupations, 28% in personal service occupations and three per cent in IT and scientific service occupations (see Supplemental Material, Table A10). Sectoral differences were found for all groups of educational qualification (see Supplemental Material, Table A11), with more pronounced disparities among men than among women (see Supplemental Material, Table A12). Additionally, VET entrants in more digitalised regions attained higher-status occupations within these sectors, as indicated by higher mean ISEI scores. This suggests that digitalisation is closely connected to occupational opportunities within the broad categories of the occupational sector.

In order to assess the extent to which the association between regional digitalisation and status attainment can be attributed to regional occupational structures, we calculated interaction models with education and gender while controlling for VET entrants' occupational sectors (see Supplementary Material, Table A13). Our results indicate that accounting for occupational sectors reduces the primary association between digitalisation and status attainment for highly qualified VET entrants by about one-third ($\beta = 0.94$; $p < 0.001$), but do not reveal variations in association by educational attainment. For men, the association between status attainment and digitalisation was reduced by about half ($\beta = 0.99$; $p < 0.001$) and the gender-specific interaction diminished ($\beta = -0.10$; $p > 0.10$). These additional analyses support our theoretical argument that region-specific occupational structures are a crucial mechanism linking regional digitalisation with status attainment.

Discussion

This study investigated the relevance of regional digitalisation for the status attainment of young people entering VET in Germany. The main finding is that the degree of regional digitalisation was a strong predictor of young people's status attainment. The results are thus in line with previous studies on the importance of regional opportunity structures for young people in the transition from school to VET (Heineck, Kleinert, and Vosseler 2011; Hillmert, Hartung, and Weßling 2017; Malin and Jacob 2019; Meyer and Winkler 2023; Schmidt and Uhly 2023; Ulrich 2013; Wicht and Nonnenmacher 2017; Wicht et al. 2024). At the same time, the study contributes to the literature on these transitions by examining the role of structural regional differences in social positioning within the VET system. Second, by using an indicator of regional digitalisation, the study also adds to the literature on skill-biased technological change, which predicts increasing skill demands for occupations and apprentices, and consequently higher-status workers (Acemoglu 1998; Frey and Osborne 2017; Oesch and Rodríguez Menés 2011; Spitz-Oener 2006).

Furthermore, subgroup analyses revealed that young people across all levels of educational qualification benefited from digitalisation in terms of status attainment. This finding contrasts with the theoretical assumption that VET entrants with upper secondary school leaving qualifications would secure higher status VET occupations regardless of the regional context. Instead, it indicates that even highly qualified VET entrants often rely on geographically accessible opportunity structures (Hoffmann and Wicht 2023a). However, the finding that also less qualified VET entrants in highly digitalised regions attain higher status VET occupations than their counterparts in less digitalised regions supports job competition theory (Thurow 1975): when the demand for highly skilled workers in more digitalised regions exceeds the supply of highly qualified VET applicants, employers may adjust their hiring practices, opting for lower qualified VET applicants from further back in the labour queue to meet their demand.

The results further reveal significant differences between genders: men benefit from higher levels of digitalisation in the region, whereas women's status attainment is comparatively unaffected. This finding is in line with our hypothesis and is linked to the generally observed horizontal gender segregation in the German VET market (BIBB 2022; Kleinert and Schels 2020; Wicht and Siembab 2022): since technical professions, which are most likely affected by digitalisation processes, are largely dominated by men, it is also men who benefit most from digitalisation. Importantly, this finding holds for urban regions only, as gender differences in associations with digitalisation were insignificant in rural regions. In terms of overall gender differences in status attainment, women on average reached higher status occupations, regardless of regional digitalisation and region type. This is consistent with previous

research on differences in status aspirations and attainment by gender, which consistently shows that women fare better than men (Miyamoto and Wicht 2020; Perry, Przybysz, and Al-Sheikh 2009; Piasna and Drahokoupil 2017; Watts et al. 2015), not least because of their choice of occupations that are considered higher-status occupations on international scales (such as nurse, a typical female occupation).

The study's additional results further stress the role of occupational structures, revealing that the impact of digitalisation and its interaction with gender decreased after controlling for occupational sectors of the VET position. This finding supports the assumption of a strong link between digitalisation processes and changing labour markets (Kropp and Dengler 2019). It implies that associations between regional digitalisation and status attainment in VET are at least partly attributable to differing occupational structures across regions. Additionally, it suggests that the prevalence of specific occupational types and fields may serve as an important mediator of regional inequalities in digitalisation.

Limitations and directions for future research

This study is not without limitations, of course. First, estimating the impact of regional digitalisation has its challenges. One is its interdependence with other regional characteristics, such as urbanity and labour market structures. We were able to mitigate this to a degree by modelling urban and rural regions separately. Theoretically, it is plausible to assume a reciprocal relationship between digitalisation and labour market characteristics, such as occupational structures or productivity (Detemple and Wicht 2024). Considering these regional labour market characteristics in the analysis could lead to overcontrol bias rather than reducing confounding biases, which is why they were not included in the main models. Nevertheless, the reported associations with regional digitalisation cannot be seen as causal. Unfortunately, it was also not possible to examine the effects of digitalisation over time to increase the strength of causal inference, as only younger cohorts were represented in the sample. It would therefore be interesting to analyse cohort differences to see to what extent increasing digitalisation affects the transition to VET.

Second, the use of ISEI as an internationally comparable measure of occupational status attainment is imperfect and carries the risk of blurring in its transferability to VET occupations on the German labour market. The main issue with the ISEI scale in the German context is that certain occupations in the health care sector, e.g. nurse, require a tertiary degree in most countries, but are a VET occupation in Germany, which to some extent inflates their status. Furthermore, the ISCO occupational codes are relatively broad, grouping together multiple occupations and masking more fine-grained differences. In general, VET occupations in Germany are very heterogeneous, and it is not easy to find an established

and internationally comparable measure that captures all relevant status-related details. Under these circumstances, however, the ISEI remained a suitable measure, as its latest version was validated using data from almost 200,000 individuals in 42 countries, including Germany (Ganzeboom 2010).

Third, the study included only those young people who were successful in finding a VET position. However, it is also possible that digitalisation-induced displacement processes have an influence on transition probability in general. This could be especially relevant for young men with the lowest educational qualifications, who find themselves competing with a larger number of higher-educated individuals in a VET market with rising skill requirements within occupations brought about by new technologies (Jacob, Kleinert, and Kühhirt 2013). Future research may analyse potential negative impacts of regional digitalisation, such as the risk of displacement.

Finally, this study was unable to test the precise mechanisms underlying the associations found between regional digitalisation and status attainment. While we theorised an increasing demand for high-skilled workers in highly digitalised regions (Acemoglu 1998, 2002), self-selection factors related to regional digitalisation may also play a role. For instance, information asymmetry might be significant, as suggested by studies on labour market literacy (Dräger and Wicht 2023; Higgins, Nairn, and Sligo 2010). VET applicants in less digitalised areas might choose lower-status occupations due to limited awareness of other local opportunities. Another supply-side factor related to self-selection could be that some young people living in more digitalised regions may anticipate a greater need for higher educational attainment due to the type of local VET positions offered. This could partly explain the stronger association between status attainment and digitalisation among those with intermediate and high educational qualifications. Unfortunately, the NEPS data does not include information on applicants' level of information regarding VET opportunities, which would be necessary to identify such mechanisms. Future research should explore these mechanisms, focusing on the types of VET occupations chosen and incorporating data on digital behaviour and perceptions of local labour markets. Another promising starting point for further research would be to develop a classification of VET occupations that reflects their relation to digitalisation processes. This would make it possible to analyse differences in associations between digitalisation-related occupations and those less affected by digitalisation processes.

Conclusion

This study shows that digitalisation marks a new fault line of social inequality between regions, demonstrating that young people in more digitalised regions attain higher status VET occupations. Digitalisation neither reinforces nor mitigates existing inequalities between VET entrants

with different school leaving qualifications. At the same time, regional digitalisation mainly affects the status attainment of male VET entrants, reducing the status attainment gap between genders in highly digitalised regions.

Given the continuing relevance of digitalisation in the labour market and its unequal regional distribution, this study has important policy implications. Measures promoting regional mobility are necessary in order to address the substantial disparities in opportunities available to young people in highly digitalised versus less digitalised regions. Such measures would help ensure access to higher-status VET positions regardless of young people's financial resources. However, since the out-migration of young people can further disadvantage structurally weak regions, improving local infrastructure is crucial to counteract outward migration and reduce regional inequality.

The results on gender differences indicate distinct trends for male and female VET entrants. The more equal distribution of occupational status between genders, as observed in highly digitalised regions, generally reflects a positive trend towards reducing gender disparity in the VET system. However, this also raises a potential concern: women may still be falling behind in perceiving or accessing the opportunities created by increasing digitalisation. To address this issue, it is crucial to encourage young women to pursue careers in fields closely related to digitalisation and technology.

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Data availability statement

The individual-level data used in this article are available to the scientific community upon request at the NEPS Research Data Center at the Leibniz Institute for Educational Trajectories (RDC-LIfBi; <https://doi.org/10.5157/NEPS:SC3:13.0.0>; <https://doi.org/10.5157/NEPS:SC4:14.0.0>). The regional data on digitalisation are derived from a formative, multifaceted measurement that combines a range of administrative data at the NUTS-3 level and is publicly available (<https://doi.org/10.5964/miss.13387>). Publicly available data on urban and rural regions come from the Federal Institute for Research on Building, Urban Affairs and Spatial Development 'INKAR' database (<https://www.inkar.de/>). The code for replicating the data preparation and analyses is available at doi:<https://doi.org/10.7802/2853>.

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