Early Career Effects of Entering the Labor Market During Higher Education Expansion*

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Abstract

We evaluate the labor market effects of an increasing supply of high-skilled labor, resulting from a higher education expansion at established German universities. Exploiting variation in exposure across regions and cohorts, we estimate early career effects for labor market entrants. We find that high-skilled wages decline initially, particularly in non-graduate jobs, but recover over the first five years of experience. Medium-skilled workers are barely affected, while low-skilled workers benefit from higher wage growth in non-routine-intensive jobs. We explain the dynamics of the effects by two countervailing mechanisms: immediate supply effects and gradual demand effects due to a more intensive use of skilled labor.

JEL Codes: I23, I26, J31, R23

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1 Introduction

The share of workers with a tertiary education degree has risen remarkably around the globe over the past decades, with many countries, such as the UK and Germany seeing increases of more than 50 percent since 2000 (see Appendix Figure A-1; OECD, 2023). According to the canonical model of the *race between education and technology*, the implications for labor market returns depend on whether or not the increase in skill supply exceeds the secular growth in demand for high-skilled labor induced by skill-biased technological change (Katz and Murphy, 1992; Goldin and Katz, 2009; Acemoglu and Autor, 2011). If the shift in skill supply is large or rapid enough, the price of skill will fall due to the downward-sloping demand curve. At the same time, however, the increasing skill supply may also endogenously induce firms to invest in new technologies to make use of the more abundant type of labor, so that the demand curve would shift outward and the price of skill would ultimately rise (Acemoglu, 1998; Beaudry and Green, 2003; Carneiro et al., 2023).[1] Thus, it is *a priori* unclear how these mechanisms add up and at which point these two mechanisms switch. For instance, the labor market adjustments to the rising skill supply could occur between or within certain entry cohorts, e.g., through changes in entry conditions, wage growth, or job mobility. Understanding these effects and mechanisms is crucial for assessing the implications of ongoing technological change, improving (higher) education systems, and designing labor market policies.

In this paper, we examine how regional labor markets adjust to increasing skill supply resulting from a higher education (HE) expansion at established institutions. We estimate the initial wage and employment effects of exposure to the HE expansion at entry and their persistence during the first five years of experience. We consider heterogeneity for different

[1] See Appendix B for a detailed discussion of the theoretical predictions.

skill groups to examine substitution and spillover effects. By focusing on labor market entrants, we can isolate the effect of increased competition for available entry-level jobs and distinguish between within- and between-cohort adjustments. To disentangle supply and demand effects—see Appendix B for a detailed discussion of theoretical predictions—we also consider employer quality, job mobility, task intensity, and heterogeneity by job type. We study this question in the context of Germany, where HE is relatively cheap and readily available.[2] In this setting, the number of first-time graduates (2002: 173,000; 2012: 310,000) as well as the share of the respective age cohort with a tertiary education degree (2002: 17%; 2012: 31%) nearly doubled in about ten years (Destatis, 2018a). In contrast to earlier HE expansions, such as in the 1960s and 1970s, this did not take place through the (government-initiated) opening of new colleges but primarily through an increase in enrollment at established institutions, preceded by increasing qualification levels of school leaver cohorts. Moreover, given the stable skill composition in the 1990s, the expansion was not anticipated in the early 2000s, as the authorities consistently underestimated the future number of university students.

We make use of detailed administrative data on individual labor market biographies from the Sample of Integrated Labour Market Biographies (SIAB) provided by the Institute for Employment Research (IAB). These data provide the exact date and location of labor market entry. In total, we observe nearly 315,000 young individuals entering the labor market between 1996 and 2015, whom we follow through their early job career (up to five years of experience). To measure the HE expansion, we use the number of college

[2] There are currently no tuition fees, and between 2006 and 2014 there were only low fees (500 euros per semester). Approximately 60% of all bachelor's programs are open to anyone who fulfills the formal requirements (basically having a *(Fach-)Abitur*) (HRK, 2021). The average distance for school leavers with a university entrance qualification to the nearest university or university of applied sciences is about 22 km (Spiess and Wrohlich, 2010).

graduates per 1,000 inhabitants within a labor market region (according to Kosfeld and Werner, 2012, and delineated by commuter links), obtained from administrative records of the Federal Statistical Office of Germany (Destatis). This indicator captures the local skill supply of universities and universities of applied sciences (UAS). We can show that the HE expansion significantly increases the skill level of the actual entry cohorts and therefore affects the labor market competition for the average entrant. Due to the uneven nature of the expansion in terms of size and speed (top decile of regions: 4.5-fold increase; bottom decile: 1.5-fold increase), we can exploit region- and cohort-specific variation in the exposure to the HE expansion at entry.

Our study contributes to three main strands of related literature. First, we add evidence to the literature on evaluating the labor market effects of HE expansions. Most of the existing studies focus on college openings as a source of exogenous variation, e.g. in the US (Currie and Moretti, 2003), Norway (Carneiro et al., 2023), Switzerland (Lehnert et al., 2020; Schultheiss et al., 2023), Sweden (Andersson et al., 2009), and Germany (Kamhöfer et al., 2019; Berlingieri et al., 2022). Other papers examine the HE expansion in the UK during the 1990s (Walker and Zhu, 2008; Devereux and Fan, 2011) and later (Blundell et al., 2022) from a macroeconomic perspective.[3] Compared to these studies, we focus on the *local* labor market effects of a HE expansion at *existing* institutions in a *high-income* country. Moreover, to our knowledge, we are the first to study the HE expansion from the perspective of labor market entrants only (rather than all workers of a certain age group).

[3]Another substrand focuses on the government-driven HE expansion in China during the 2000s (Fu et al., 2022; Huang et al., 2022; Piracha et al., 2022; Ma, 2024).

Second, we complement the literature on graduating during a recession (see von Wachter, 2020, for an overview).[4] To the best of our knowledge, this literature has focused mainly on recessions, while other (adverse or favorable) labor market entry conditions, including increases in skill supply, have received less attention.

Third, our work relates to the literature on long-term changes in the skill composition of the labor market and their implications for returns to education. While Card and Lemieux (2001), Biagi and Lucifora (2008), Kleinert and Jacob (2013), and Glitz and Wissmann (2021) take a more aggregate perspective, Beaudry et al. (2014, 2016) for the US and Reinhold and Thomsen (2017) for Germany focus specifically on young workers. We update their evidence of the "declining fortunes of the young" with more recent data, which allow the detection of potentially delayed effects of the HE expansion.

2 Data and Sample Selection

2.1 Statistics of Examinations

To track the HE expansion at the regional level, we draw on the *Statistics of Examinations* from Destatis (Destatis, 2018b) that contains information on all final examinations passed at publicly acknowledged HE institutions in Germany. These data are collected for each institution and for each academic year (winter term plus following summer term). We focus on universities and UAS (hereafter collectively referred to as universities), which accounted for about 95 percent of all graduates in 2017.[5] Each university and UAS is

[4]In particular, Kahn (2010), Oreopoulos et al. (2012), Altonji et al. (2016), Schwandt and von Wachter (2019), Huckfeldt (2022), Rothstein (2023) for North America; Arellano-Bover (2022) for 19 countries; Umkehrer (2019) for Germany; and Fernández-Kranz and Rodríguez-Planas (2017) and Bentolila et al. (2022) for Spain.

[5]We exclude other types of institutions, such as colleges of theology, colleges of art and music, colleges of education, and colleges of public administration. Graduates from these schools are mostly headed for different labor markets, such as civil service, so they are not covered in the SIAB data (see below).

then assigned to one of the 141 German labor market regions (see below) and graduation numbers are aggregated by region and year.

Since we study a relative increase in skill supply, it seems natural to define our treatment accordingly. Therefore, we relate the number of first-time graduates to 1,000 inhabitants per region, hereafter referred to as the HE expansion rate.[6] The HE expansion rate captures the regional variation in the skill provision of local colleges, changing the individual position in the labor queue and allowing us to study the response of the affected individuals and firms to this change. Focusing on the supply side and using the skill composition of graduate cohorts—rather than the actual skill composition of the workforce or of entry cohorts—has the advantage of being less prone to endogeneity: First, the number of graduates is primarily determined by institutional constraints and the choices of school leavers eligible for college (see Section 3.1). Second, measuring the expansion as outflows from the HE system (rather than inflows into the labor market) reduces concerns about selection into the timing and region of labor market entry.

2.2 Sample of Integrated Labour Market Biographies (SIAB)

To follow labor market entrants throughout their early job careers, we make use of the SIAB (Antoni et al., 2019a), a representative 2% random sample of all employees subject to social security contributions in Germany.[7] It represents approximately 80% of the labor force in Germany, excluding, e.g., civil servants, soldiers, and the self-employed. The SIAB

Correspondence colleges are also excluded as they do not require on-site presence and graduates cannot be located in a certain region.

[6]As alternative measures, we also used the number of first-time graduates per 1,000 employees and the log number of first-time graduates. This does not alter our results significantly. To avoid double counting, we only focus on first-time graduates, i.e., those with either a bachelor's (BA) or a former degree from a university or UAS (e.g., Diplom or Magister). Graduates with second- or third-cycle degrees (master's and doctoral degrees) are therefore excluded. We do the same for graduates with a teaching certificate, as they aim for the civil service and are not covered in the SIAB.

[7]See Antoni et al. (2019b) for a detailed description of this data source.

contains detailed and daily information on wages and employment status combined with certain individual (e.g., skill, occupation) and firm characteristics (e.g., industry, place of work). In this way, we are able to capture the labor market trajectories of entrants with a high level of detail and precision.

For working with the SIAB, we apply common preparation and imputation steps that are explained in detail in Appendix C. First, we use the imputed education variable to group workers into three different skill levels: low-skilled (i.e., without vocational training), medium-skilled (i.e., with vocational training) and high-skilled (i.e., with a tertiary education degree). Second, censored wages above the upper earnings threshold for compulsory social insurance (e.g., 76,200 euros per year in West Germany, and 68,400 euros per year in East Germany in 2017) are imputed by applying the 2-step procedure suggested by Dauth and Eppelsheimer (2020).

Our main outcome variables are the log real daily wage of full-time workers and the log number of days in employment subject to social security contributions per experience year (henceforth annual days employed). To investigate the mechanisms of potential wage and employment effects, we further consider measures of job mobility, employer quality, and task intensity. The construction of all outcome variables is explained in detail in Appendix C.

2.3 Sample Definition and Aggregation Level

We define labor market entry as the first day of employment subject to social security contributions, excluding entries into vocational training. To avoid measuring only a temporary entry, we count labor market entry for low-skilled workers only if they do not reach a higher educational level or start an apprenticeship within the next five years.

We also exclude atypical employment biographies and drop those who enter the labor market younger than 16 and older than 30 years. In line with our graduation data, we restrict the sample to those entering the labor market between 1996 and 2017.

We convert the spell data into a panel format by using the exact day of entry as the cutoff date and by slicing the data set each year after labor market entry (up to five years of (potential) work experience). This procedure provides us with day-precise and fully comparable measures of the years of experience of the labor market entrants. That is, a worker's first experience year begins on the day of entry and lasts for exactly one year.

However, not all workers are observable in the SIAB in each year over their first five years of experience. For instance, some individuals may die, leave the country, or drop out of the labor force completely. To limit any potential bias from this, but to maintain a good balance between obtaining a sufficient sample size and being not too restrictive and selecting only the "survivors" in the labor market, we consider only those labor market entrants who are observable in at least one other period (in addition to the labor market entry). This restriction reduces the sample size by less than 20 percent.[8] In total, we observe 314,973 labor market entrants between 1996 and 2015[9] in our sample.[10]

Finally, we merge the graduation data with the individual labor market data at the workplace level. We use 141 labor market regions delineated according to Kosfeld and Werner (2012). These labor market regions are defined by commuter links and represent homogeneous functional areal units that reflect actual economic conditions better than administrative units such as districts. Therefore, it is reasonable to assume that the

[8] In the robustness section, we show that this is unlikely to drive the results, as we find qualitatively similar results for both a completely unrestricted and a fully balanced sample.

[9] Since our sample restrictions require at least two observations, all entrants from 2017 are dropped. The year 2016 is also excluded to have balanced two-year bins for the skill-specific effects.

[10] See Appendix Table C-1 for a detailed overview of the sample size by entry cohort and Appendix Table C-2 for the respective numbers *before* sample restrictions.

place of work and the place of residence are located in approximately the same region. For control variables and balancing checks, we supplement the resulting data set with regional characteristics, such as the unemployment rate, obtained from INKAR (BBSR Bonn, 2019) and the Regional Database of Destatis (Destatis, 2019).

3 Descriptive Patterns

3.1 HE Expansion

After a period of a moderate decline (1996-2000), the number of *first-time* graduates increased from approximately 177,000 to 311,000 between 2000 and 2017 (+76%), with a peak in 2015 (see Panel A of Appendix Figure A-2). In relative terms, the proportion of an age cohort achieving a tertiary education degree rose from 17% (2000) to 32% (2017) (Destatis, 2018a). This HE expansion was quite universal and affected all groups of students, although to varying degrees and at different paces. The increase was higher for women (Panels A-B of Appendix Figure A-2), for students at UAS (Panels C-D), and in the east (at least until 2011) and in the south of Germany (Panels E-F). While first-time graduates in humanities and in natural sciences initially increased more strongly, but also peaked earlier, social sciences and medicine recorded a steady increase until the end of the observation period, reaching a level similar to that of the aforementioned areas (Panels G-H).

Although new (branches of) institutions were also established during this period, the expansion resulted mainly from increasing enrollment at existing universities and UAS—in contrast to the expansion in the 1960s and 1970s. About 80 percent of the total increase in first-time graduates in our sample between 2004 and 2017 can be attributed to existing institutions and only about 20 percent to the establishment of new ones. For instance, the Technical University of Munich, one of the largest universities in Germany, more than doubled its number of first-time graduates from approximately 2,100 (2000) to 4,500 (2017).

There is much debate in the literature about the extent to which the HE expansion in Germany was driven by policy changes such as the Bologna reform (Kroher et al., 2021), the *G8* reform[11] (e.g., Marcus and Zambre, 2019; Meyer et al., 2019), or the introduction and abolition of tuition fees (e.g., Bietenbeck et al., 2023). Yet, the preceding increase in the qualification level of school leavers suggests that a large part is explained by rising educational attainment of the youngest generations. The share of an age cohort that acquires the formal qualifications to enter HE (*(Fach-)Abitur*) increased significantly (2000: 37%; 2017: 51%), followed by an increase in the share of an age cohort that actually enrolls in HE (2000: 33%; 2017: 57%) (see Figure 1).

< Insert Figure 1 here >

This was not expected by the authorities. The Standing Conference of the Ministers of Education and Cultural Affairs (*Kultusministerkonferenz*) regularly forecasts the number of high school graduates as well as the numbers of first-year students, students, and graduates. These forecasts serve as the main information base for the allocation of HE resources. In 2003, the projections expected only a moderate increase in HE qualification and enrollment rates (see Figure 1; KMK 2003). Two years later, and in light of the reforms of school duration passed in many federal states (*G8* reform), this was revised upward, but was not expected to become a permanent increase (KMK, 2005). Therefore,

[11] The *G8* reform reduced the mandatory time to obtain a HE entrance qualification from 13 to 12 years. It was implemented by most German federal states between 2001 and 2008, leading to double cohorts in several years.

it was not until 2007 that the federal and state governments provided universities with additional financial and personnel resources as part of the so-called *Higher Education Pact 2020* to handle the rising student numbers. Due to this delayed expansion of funding, the number of first-time graduates per professor and per scientific staff initially rose until around 2009, and the current expenditures per first-time graduate fell vice versa. Since then, the situation has improved noticeably (see Appendix Table A-1). This clearly highlights that the expansion was neither resource- or investment-driven nor was it anticipated by the authorities—at least not to its full extent.

At the regional level, the HE expansion occurred at different speeds and to different extents.[12] Figure 2 presents its evolution by the 10^{th}, 25^{th}, 50^{th}, 75^{th}, and 90^{th} percentile. At the median of the distribution, the number of first-time graduates per 1,000 inhabitants almost doubled from 1.7 (2000) to 3.2 (2017) (see Panel A). This increase took place mainly between 2002 and 2010 and was quite similar for all percentiles considered, albeit with varying absolute intensity (bottom decile: +1.0; top decile: +2.6). Independent of the initial size of the university region, there were also large differences in the dynamics of the HE expansion across labor market regions (see Panel B). While the top ten percent of the regions showed a 4.5-fold increase in the number of first-time graduates per 1,000 inhabitants, the bottom ten percent of regions expanded by a factor of about 1.5.

< Insert Figure 2 here >

[12] From our sample of 141 labor market regions, between 84 (2000) and 96 (2017) regions contain more than 50 first-time graduates from universities or UAS (BA or a former university or UAS degree) and are thus considered as university regions (see Appendix Figure A-3).

3.2 Rising Skill Supply in the Labor Market

In the course of the HE expansion, the skill level of labor market entry cohorts increased steadily. While in 2000, 10% of labor market entrants had an academic qualification, their share rose to 18% in 2017 (see Appendix Figure A-4).[13] At the regional level, we also observe this pattern and can relate it to the presence of universities—either directly through the qualification of future workers or indirectly through skill sorting: Appendix Table D-1 shows that the HE expansion rate significantly increases the skill level of entry cohorts in a region. A one-unit increase in the HE expansion rate leads to a 0.56 percentage point higher share of high-skilled among all labor market entrants, conditional on region and year fixed effects and the unemployment rate. Moreover, in terms of the skill level of the entire labor force, we find that those labor market regions where more students graduated in total between 2000 and 2017 experienced a larger increase in the share of academic qualifications during the same period (see Appendix Figure A-5), supporting the skill-raising channel of universities.

However, the variation in the local HE expansion can explain at most 50 percent of the variation in the local change in the skill composition of the labor market (see R-squared in Appendix Figure A-5). This points towards two important abstractions: First, there is regional migration. For German regions defined on a broader geographical scale than our regions, Buenstorf et al. (2016) estimate that more than half of college graduates leave their graduation region for their first job, while about 43 percent stay. Second, there are delays in entering the labor market due to the continuation of HE. In 1999, the so-called Bologna Process was initiated and in the course of this, the traditional one-cycle degrees were successively replaced by two-cycle degrees in Germany (see Appendix Figure

[13] Due to the educational catching-up of labor market entrants, this share is likely to be underestimated.

A-6). Therefore, new college-educated labor market entrants were split into three different groups: i) those who enter the labor market with a former degree (continuously decreasing to 15% of all first-time graduates in 2018), ii) those who enter the labor market directly after BA graduation (approximately 35% of all first-time graduates in 2018), and iii) those who enter the labor market after MA graduation (approximately 50% of all first-time graduates in 2018).[14] We will discuss a potential bias through these composition effects later in Section 5.5.

3.3 Rising Fortunes of the Young (Again)

Finally, we describe the evolution of wage profiles of labor market entry cohorts by skill group (see Figure 3). As is well known, wage profiles start steeply and then level off with increasing years of experience, with profiles for high-skilled individuals starting at a higher level and rising faster than wage profiles for medium- and low-skilled individuals. For instance, full-time wages of high-skilled labor market entrants in our sample increase on average by about nine percent per year over the first five years of experience, while those of medium-skilled increase by about five percent per year only.

However, there are striking differences across entry cohorts. Entry wages and wage growth have declined considerably between the mid-1990s and the mid-2000s. This pattern is well documented in the literature as the "declining fortunes of the young" in the US (Beaudry et al., 2014, 2016) and in Germany (Reinhold and Thomsen, 2017). Our findings indicate that this process has stopped and that the fortunes of the young are rising again. Since 2007, wage profiles have extended and steepened substantially, and

[14] Teaching and other degrees are excluded. Numbers are given for 2018, as Destatis then published administrative BA-MA transition rates for the first time (Destatis, 2021). Previously, there was only evidence from surveys, such as the DZHW Graduate Panel 2013, which, however, reported a much higher transition rate of 62% of BA graduates who continued with an MA program within 1.5 years of their BA graduation (Fabian et al., 2016).

entry wages have also risen with some delay. However, this development mainly affected low- and medium-skilled entrants, while the wage profiles of high-skilled workers increased relatively late and slowly.

< Insert Figure 3 here >

4 Empirical Strategy

Since our main source of variation is on the regional level, we follow the literature on early career effects (e.g., Oreopoulos et al., 2012; Schwandt and von Wachter, 2019) and collapse the individual labor market data to cell means at the level of region of workplace at entry (r), year of labor market entry (cohort) (c), and year of experience (e). To investigate skill heterogeneity, we additionally collapse at the level of skill groups (s) and work with two-year bins to increase cell size. The HE expansion rate is then matched to the labor market outcomes at the year and region of labor market entry. Our cell-level baseline model can be written as follows

$$\bar{y}_{r,c,e} = \alpha + \beta_e HE\ expansion_{r,c} + \gamma_e + \lambda_r + \delta_c + \theta_t + \phi ur_{r,c} + \epsilon_{r,c,e}, \quad (1)$$

where $\bar{y}_{r,c,e}$ is the cell mean of the respective outcome variable (weighted by the respective cell size) in region r at year of labor market entry c and experience year e. β_e represent our main coefficients of interest and give the effect of the initial HE expansion rate ($HE\ expansion_{r,c}$) varying by years of labor market experience (e). γ_e, λ_r, δ_c, and θ_t are fixed effects for year of labor market experience, region of labor market entry, year of labor market entry (cohort), and calendar year. Additionally, we use the unemployment rate ($ur_{r,c}$) in year and region of entry to control for labor market conditions that may affect cohorts differently (e.g., Oreopoulos et al., 2012; Schwandt and von Wachter, 2019). Robust standard errors are clustered at the cohort×region-level ($\epsilon_{r,c,e}$), where the treatment is assigned.

Conditional on the considered fixed effects and the unemployment rate, the coefficient vector β_e represents deviations from typical experience profiles due to cohort×region–specific variation in the HE expansion rate at labor market entry. The estimates can be viewed as a reduced form, as we measure the outflow from the HE system on the right-hand side regardless of region and year of labor market entry to reduce the endogeneity concerns. However, for a causal interpretation of β_e, we have to assume that the HE expansion rate is independent of other determinants of labor market outcomes of young workers. In our case, there are at least two potential threats to this identification strategy: a) endogenous timing of and migration at labor market entry, and b) endogenous HE expansion.

4.1 Endogenous Timing of and Migration at Entry

For our baseline specification, it seems reasonable to assume that labor market entry (measured day-precise using the SIAB) is exogenous. However, individuals may delay or accelerate their labor market entry in response to conditions they perceive as (un-)favorable to their chances of starting a job. For instance, students may stay in college a few semesters longer or take a gap year after graduation, if they are placed within a large cohort. In addition, we measure exposure to the HE expansion at the region of entry. Thus, we implicitly assume that the location of graduation from school, apprenticeship, or college and of labor market entry are the same. Since we use labor market regions delineated by commuter links, this may hold for less mobile groups, such as school graduates who enter the labor market without further education. However, college graduates frequently migrate after graduation—either back to their home region (return migrants) or to new locations (repeat migrants) (see Section 3.2).

To address these concerns, we check for selection into timing and region of labor market entry by first regressing the month of labor market entry as well as the gender and age composition on the HE expansion rate. These results are shown in Appendix Tables D-2 and D-3. We find no apparent correlations between the HE expansion rate and the month of entry, ruling out a potential delay of entry within a calendar year, which could lead to a seasonality bias in the effects. There is also no evidence of selective timing in terms of the gender and age composition—at least for the low- and high-skilled. Yet, the HE expansion rate seems to be significantly correlated with the age of medium-skilled labor market entrants. But as the length of apprenticeship is relatively fixed, this is likely to be related to composition effects rather than endogenous adjustment of the timing of labor market entry. The increasing qualification level of school-leaver cohorts that precedes the HE expansion should also lead to an increase in the age of medium-skilled entrants.

Second, we follow Oreopoulos et al. (2012) and predict year and region of labor market entry by observable characteristics. Regarding the timing of entry, we use information on birth year and highest educational attainment to compute a hypothetical year of labor market entry, if individuals had followed common educational pathways.[15] The deviations from actual labor market entry are presented in Appendix Figure D-1. Although there are substantial differences between the actual and the predicted year of labor market entry by about 2.7 years on average, these differences are relatively constant over time. For the

[15] We use 19 years for low-skilled, 20 years for medium-skilled, and 26 years for high-skilled individuals.

high-skilled, however, there is a declining trend in the difference, presumably reflecting the changes due to the Bologna reform that allows to enter the labor market much earlier.

Regarding the region of entry, we proxy the unknown place of graduation with previous work experience. For low-skilled workers, we use the very first employment spell in the data as an indication of the region of residence and therefore of graduation from high school. For medium-skilled workers, we can identify the exact location of graduation through the previously completed apprenticeship, which is recorded in the SIAB. Since about two-thirds of students work while studying (Middendorff et al., 2017), we exploit information on previous marginal employment for high-skilled workers, assuming that it is a student job close to the region of residence during academic studies. The evolution of the available information used to predict the region of graduation and the resulting migration rates are presented in Appendix Figure D-2. As can be seen, we have sufficient information on previous employment to predict the region of graduation (about three-quarters of all labor market entrants). However, data on marginal employment are not reliable until 1999, so this holds only from 2004 onwards for high- and low-skilled. Since then, migration rates of high-skilled labor market entrants have been around 45 percent, exceeding those of medium-skilled and low-skilled. Finally, as a robustness check for our baseline estimates, we match the HE expansion rates to the labor market data based on the *predicted* year and region of graduation to estimate the exposure effect before potential selection in timing and migration.

4.2 Endogenous HE Expansion

As shown in Section 3.1, the HE expansion in Germany occurred to some extent unexpectedly. In particular, it was not government-driven by an expansion of resources but resulted from increasing educational attainment of school graduates. Nevertheless, a potential concern is the sorting of students into particular university regions. For instance, high school graduates may selectively move to regions where amenities increase endogenously due to skill-biased productivity changes. These, in turn, positively affect the labor market outcomes of both young and incumbent workers, which would lead to an upward bias in the effect. At the same time, the true estimates could also be underestimated once HE expands especially in regions that simultaneously attract young people beyond university students, thereby increasing the competition for the entire age group.

Appendix Tables D-4 and D-5 demonstrate that the HE expansion indeed occurred quite independently of regional economic and sociodemographic developments. The exception is the correlation with the share of the young population, which to some extent should be mechanically related to the HE expansion, but could also point to coinciding immigration of the young population. Regions with a greater HE expansion were also more densely populated, had a lower unemployment rate and a larger share of the young population initially.

To further address the potential endogeneity problem, we construct a shift-share instrument for the HE expansion rate. Its construction, validity, and the results are discussed in Appendix D, which provides qualitatively similar results.

5 Empirical Results

5.1 Wage Effects

Figure 4 presents our main results for wages: the effect of the HE expansion rate on the log real daily wage of full-time workers, varying by year of labor market experience.[16] We present estimates both for the full sample of labor market entrants (Panel A) and for the different skill groups (Panels B-D). Gender and occupational heterogeneity is shown in Appendix Figure E-1.

< Insert Figure 4 here >

Figure 4 provides evidence of a small negative wage effect of the HE expansion at labor market entry (see Panel A). In the OLS specification (in blue), we estimate that the exposure to a one-unit increase in the number of first-time graduates per capita (slightly less than the total HE expansion of the average region: 1.3) leads to –0.8% lower full-time daily wages. Compared to a typical recession, which costs about ten percent of earnings (von Wachter, 2020), this effect seems to be relatively small. However, it equals the average yearly real wage growth during the period 2008 and 2017 (Destatis, 2024), and is therefore not economically negligible. On top of that, as we will show below, the average effects mask substantial heterogeneity across subgroups.

With more work experience, the initial negative effect diminishes, turns positive, and increases in magnitude. Thus, cohorts entering the labor market during HE expansion have steeper wage profiles (starting lower but rising faster). After five years, a one-unit

[16]The exact coefficients and standard errors are reported in Appendix Tables E-1 and E-2, where we also provide specifications with fewer fixed effects and no unemployment rate to demonstrate the robustness of the results.

increase in the HE expansion rate raises full-time daily wages by +0.5%. In sum, labor market entrants are about equally off at the end of the career phase considered.

Turning to the effects for the different skill groups reveals some heterogeneity (see Panels B-D of Figure 4): The initial negative wage effect is clearly driven by high-skilled labor market entrants (–1.1%). With more experience, this effect fades out and turns positive five years after labor market entry. If we consider log daily wages of *all* employees subject to social security contributions (not only full-time), we even find noticeable positive effects after five years of experience (+1.5%) (see Appendix Figure E-2). This divergent pattern suggests changes at the intensive margin of employment. Indeed, we report a higher propensity of high-skilled workers to be employed part-time at the beginning of their career, but a lower propensity after five years (see Appendix Figure E-2). Since we find this pattern for both men and women, it cannot be explained by gender effects. Instead, it seems to be related to a sector effect. Due to the HE expansion, we find a higher propensity to enter the HE system (see Appendix Figure E-3), where about 40 percent of young researchers are employed part-time (BuWiN, 2021). This explains the increase in part-time employment of high-skilled workers at the beginning of their careers. After a few years, most of them leave the system to take a full-time job. Thus, to some extent, the HE expansion appears to create its own supply of high-skilled jobs.

In contrast, the wage effects for medium-skilled workers are much closer to zero throughout the early job career (see Panel C of Figure 4). For low-skilled labor market entrants (see Panel D), however, we observe large and positive full-time wage gains after the first year of experience (+2.1%), which persist and increase further to +2.5% after five years of experience. We find these effects for both men and women, although they are much larger for the latter after five years (+1.2% vs. +4.9%) (see Appendix Figure

E-1). The gender differences are likely to arise from occupational heterogeneity, with female-dominated jobs such as professions in health care, social work, and education showing large wage gains (see Appendix Figure E-1).

5.2 Employment Effects

Having observed responses at the wage level, we now turn to employment effects. Since we condition on labor market entry, we cannot identify any effects on the probability of being employed in the first place (extensive margin). However, we can analyze how *much* individuals work during the first five years of experience (see Figure 5) and how their employment status develops over time (see Appendix Figure E-4).

< Insert Figure 5 here >

As noted above, we have already identified changes in hours worked per day by the high-skilled due to the HE expansion. On top of that, there also seem to be adjustments in terms of annual days employed per experience year. Overall, labor market entrants are employed more days during their first year of experience (+1.2%), which persists (to a slightly lower extent) until the fifth year (+0.9%) (see Panel A of Figure 5). Looking at the differences between skill groups (see Panels B-D), the employment effects seem to be driven by medium-skilled workers (and low-skilled workers in the beginning). This effect comes both from lower unemployment and lower dropout of the labor force covered by the SIAB (see Appendix Figure E-4) and is almost exclusively found in manual jobs (medium-skilled) and in unskilled service jobs (low-skilled).

In return, while there is no change in the number of days employed subject to social security contributions for the high-skilled, they are increasingly unemployed over the early career path (see Panel B of Figure 5). Nevertheless, the unemployment rate remains at a very low level ($< 2\%$).

5.3 Job Mobility, Employer Quality, and Task Intensity

Based on our theoretical reasoning in Appendix B, we examine three potential channels that may explain how high-skilled labor market entrants recoup their initial losses and how medium- and low-skilled benefit from increases in employment and wages after some years of experience, respectively. We focus on i) job mobility in terms of more frequent or more efficient switching of firms, regions, or occupations, ii) employer quality measured in average firm size and average firm wage level, and iii) task intensity of the jobs performed. In general, we do not find striking changes in the job mobility and employer quality of labor market entrants due to the HE expansion that help to explain the identified wage effects (see Appendix Figures E-5 and E-6). Nevertheless, there are some notable patterns. First, the employer size of high-skilled labor market entrants decreases over the first five years of experience. However, since we do not find any comparable differences in job mobility, this suggests that high-skilled workers tend to leave larger firms more often and move to smaller ones. This is consistent with the sector effect identified above of a higher initial propensity to enter the HE system with typically large firm sizes. Second, workers who enter the labor market during HE expansion perform significantly more interactive non-routine tasks and significantly less cognitive routine tasks, driven by the high-skilled group (see Appendix Figure E-7). Distinguishing by skill group shows that the effects are clearly driven by high-skilled workers. These effects mostly emerge directly at labor market entry and persist over the first five years of experience. This indicates a supply-driven rather than a technology-driven change, as the changing task composition occurs between entry cohorts rather than within.

5.4 Discussion

Our analysis thus far has shown that there are initial wage losses for high-skilled workers due to the HE expansion, and that these losses are recouped over the first five years of experience. Low-skilled labor market entrants benefit from increases in wages after a few years of experience. In light of our theoretical predictions (see Appendix B), we interpret this as the result of a supply effect that is overtaken by a skill-biased demand effect, as discussed below.

Supply Effect

As suggested by *cohort crowding* and *positional value theory*, increases in skill supply lead to downward pressure on wages (and vice versa). This is reflected in our ranking of entry wage effects from negative (high-skilled) to zero (medium-skilled) to positive (low-skilled), consistent with the observed changes in skill supply. While we find only little changes in entry conditions in terms of employer quality, according to these theories, the increasing skill supply implies a prolongation of the queue for jobs that require graduate skills. Assuming that labor demand is fixed in the very short run, some university graduates would then be pushed into jobs that do not require graduate skills, commonly referred to as overeducation (Leuven and Oosterbeek, 2011). Therefore, we investigate the effects of the HE expansion on the probability of being employed in a graduate job, based on the use of general skills.[17] For high-skilled workers, non-graduate jobs mainly consist of less

[17] We define a graduate job according to Green and Henseke (2016) and Henseke (2019) as one where "[...] a substantial portion of the skills used are normally acquired in the course of higher education

complex clerical positions. After accounting for increased entry into the HE system, we find a significantly lower probability for high-skilled workers to be employed in a job that reflects their qualifications (see Figure 6).

< **Insert Figure 6 here** >

These job types are also associated with different changes in wage profiles due to the HE expansion. We report large negative wage effects only for high-skilled workers starting in non-graduate jobs, while there is clear evidence of no such effects for those starting in graduate jobs (see Figure 7). Overall, this supports the interpretation that the HE expansion is detrimental to those graduates who are pushed into non-graduate jobs due to increased competition for available jobs.

< **Insert Figure 7 here** >

Moreover, as also implied by the theories, the extent of the downward pressure on the wages of lower skilled groups should depend on their substitutability with high-skilled workers. In general, we would expect limited substitutability, reflected in the identified hierarchy of wage effects across skill groups. However, medium-skilled workers could also be affected by the higher skill supply, if they compete for jobs requiring general skills. In fact, we estimate large negative wage effects for medium-skilled workers in graduate jobs (particularly high complex clerical positions), while the coefficients for non-graduate jobs are very close to zero (see Figure 7). Thus, consistent with the *positional value theory*, the value of education seems to be context-specific, and a relative increase in the supply of a highly-skilled group can also lead to a downranking of lower-skilled individuals. For the German context, with its well-established dual apprenticeship system, we consider

[...]" (Green and Henseke, 2016, p.3). This means in particular generic skills such as problem solving or research skills.

the substitution of medium- and high-skilled workers particularly plausible in clerical jobs, where the Bologna reform induced an up-skilling (Thomsen and Trunzer, 2024). In return, technical jobs seem to shield medium-skilled workers more from the increasing competition due to the HE expansion.

To rule out alternative explanations (such as changes in ability or quality of HE), we consider gender and occupational heterogeneity (see Appendix Figure E-1). For high-skilled workers, we find significant negative entry wage effects for both genders. The estimates for occupational subgroups are also consistently negative, but much less precise due to smaller sample sizes, with larger effects for technical and service occupations. Thus, it seems unlikely that selection patterns, such as more women among university graduates or shifts across specific fields of study, alone can explain the observed patterns. The same applies to changes in the quality of HE due to the declining student-staff ratio (see Section 3.1), which was particularly strong in STEM (Dohmen, 2014).

Finally, the results imply a small role of labor market institutions, but for some economic sectors wage rigidities should matter. Therefore, we divide workers into those who are employed in the public sector where all wages are subject to collective bargaining agreements, and those who are not. For these workers, initial wage effects should be much smaller or even non-existent. Indeed, this is exactly the case: Negative wage effects are found only for workers starting in sectors other than the public sector (see Figure 7).

Demand Effect

Looking beyond entry into the early career phase up to five years of experience, we argue that our results are more consistent with skill-biased (and to a lesser extent routine-biased) technological change. The positive wage effects for the low-skilled may well reflect the increasing scarcity of unskilled labor due to the HE expansion in areas of high labor demand (health care, social work, and education). This leads to a higher retention of low-skilled workers in the labor market and in high-paying firms, resulting in strong wage gains after five years of experience. For the high-skilled, the wage profile pattern of workers in non-graduate jobs is very similar to that of regionally mobile workers (see Figure 7). This could indicate that some part of the wage recovery process is related to regional mobility. However, looking only at regional stayers, there is a continuous positive wage growth pattern (see Figure 7), suggesting slowly increasing labor demand for high-skilled labor. Within the group of high-skilled, there are significant positive effects on full-time daily wages after five years (+1.0%) only for graduate jobs, while for non-graduate jobs the effects are close to zero and even negative (see Figure 7).

There is also evidence of a routine bias in the effects, although it is less apparent. Distinguishing jobs into routine-intensive and non-routine-intensive based on task usage (Dengler et al., 2014) shows that the wage profile effects are steeper in non-routine jobs than in routine jobs for high- and low-skilled labor market entrants (see Figure 7). However, for medium-skilled workers it is vice versa and the patterns for low-skilled workers closely correspond to the occupational patterns identified above.

Finally, to rule out that the catching-up process can be explained by employer learning / on-the-job-screening (*assortative matching*), we distinguish labor market entrants by ability. We proxy ability by predicting wages with a Mincer-type regression based on age, gender, and occupation, conditional on region and year fixed effects. Since individuals are likely to be sorted into occupations, these estimates capture both differences in innate ability and differences in occupational premiums. We then group individuals into tertiles based on these predicted wages (Oreopoulos et al., 2012). We find wage growth in both the bottom and the top quantile, making it less likely that the catch-up process is driven solely by employer learning about the true productivity (see Appendix Figure E-8).

5.5 Robustness Checks

Endogenous Timing of and Migration at Labor Market Entry

As discussed in Section 4.1, we check for endogenous timing of and migration at labor market entry by matching HE expansion rates to the outcomes of labor market entrants in the predicted year and region of graduation. These results are presented in Appendix Figure F-1 and measure the exposure to the HE expansion at graduation rather than at labor market entry. Labor market entrants can evade that by moving or by accelerating/delaying their entry to some extent. Compared to our baseline estimates, we do not find initial negative wage effects in either the full sample or the high-skilled sample. This result is mainly explained by the region of graduation (and less by the timing). Since the negative wage effects at labor market entry move towards zero, this suggests a negative selection of labor market entrants into more expanding regions.

Interactions with the Bologna Reform

As pointed out in Section 3.2, the parallel introduction of the two-cycle system of BA and MA degrees in Germany may represent a confounding factor that changes the composition of graduate cohorts unequally across regions and cohorts. Therefore, we analyze whether the Bologna Process (measured as the share of BA graduates per first-time graduation cohort) accelerates or curbs the effect of the HE expansion. The estimates from interacting the HE expansion rate with the share of BA graduates are presented in Appendix Table F-1.

Overall, the initial wage effect is supported. Accounting for the composition of graduates reduces the initial negative wage effect only slightly to –0.7%. The wage gain after five years also remains stable at +0.6%. However, on top of the entry effect, we find some evidence of an additional negative effect of –0.2% on entry wages due to an increase in the share of BA graduates by 10% (roughly the average annual implementation of the Bologna Process). This is in line with empirical evidence (Kroher et al., 2021) that the new BA graduates are paid lower wages than the former graduates.

Bias through Sample Selection and Panel Attrition

Another concern with the results presented so far is that the sample restriction we have imposed (at least two years observed in the SIAB) leads to sample selection bias. Therefore, we re-estimate our main results for a completely unrestricted sample that includes all labor market entrants who are employed subject to social security contributions at entry. Moreover, we go to the other extreme and use only labor market entrants who are observed in *each* of the first five years of experience, leading to fully balanced panels of workers across experience years. As shown in Appendix Figure F-2, these different sample restrictions do not change the overall patterns of our results, thus ruling out potential concerns regarding our sample definition.

6 Conclusion

In this paper, we examine how local labor markets, and in particular labor market entrants, adjust to the exposure of increasing skill supply. Thus far, several prevailing theories and existing empirical evidence predict two opposing mechanisms with unclear aggregate and dynamics of the effects: i) downward pressure on wages (*supply effect*), and

ii) wage increases due to more intensive use of the more abundant type of labor (*demand effect*).

Our results provide evidence in support of both mechanisms. Due to the HE expansion, high-skilled workers experience downward pressure on entry wages. While those workers who start in graduate jobs are unaffected at entry (for which, however, the probability of being employed decreases), the effect is driven by those who are employed in non-graduate jobs. Lower-skilled individuals are only negatively affected when competing for similar types of jobs (i.e., graduate jobs). After a few years of experience, the initial wage losses fade out. For high-skilled labor market entrants working in graduate jobs, we even find positive wage effects after five years. There is also some evidence of beneficial effects for lower skilled workers, especially in non-routine intensive jobs in the health and education sector. Thus, it seems plausible that the steeper wage profiles are linked to an endogenously increased demand for skilled labor and non-routine tasks.

Altogether, we show that it is important to consider the early career path of labor market entrants—not just average effects at entry or for broadly defined age groups—in order to understand the changes induced by the HE expansion. While the observed trend of HE expansion in Germany is quite general for many OECD countries, our results reveal three peculiarities of the institutional setting that lead to different implications and also help to explain differences to existing studies. First, in contrast to previous related papers finding no (e.g., Walker and Zhu, 2008; Berlingieri et al., 2022) or lagged negative effects (Carneiro et al., 2023), we focus on labor market entrants and on an expansion at pre-existing institutions. Thus, the treatment intensity and the immediate skill supply shock are much larger in our setting. Against this background, the observed wage kink still appears to be relatively small (and, moreover, is only temporary), so that the fears of a massification of HE raised in public debates do not seem justified. Second, since the cohort crowding mechanism is found to be highly context-specific, the potential spillovers to lower-skilled individuals depend on the similarity of tasks performed. In Germany, with its strong dual apprenticeship system, this implies that high-skilled labor market entrants going into less complex clerical jobs compete with medium-skilled labor market entrants who received on-the-job training. Third, migration at labor market entry and during the early career phase can be an important means of reinforcing or reducing the identified mechanisms. Hence, countries expanding their HE systems should therefore be aware of the short-term frictions at the expense of some groups and consider measures to reduce their pervasiveness by promoting job mobility and matching efficiency.

While this paper concentrates on early career effects from the perspective of workers, promising avenues for future research include considering medium- to long-term effects (> five years of experience) and focusing on adjustments by firms in terms of entries/exits, job creation, labor productivity, and R&D investment.

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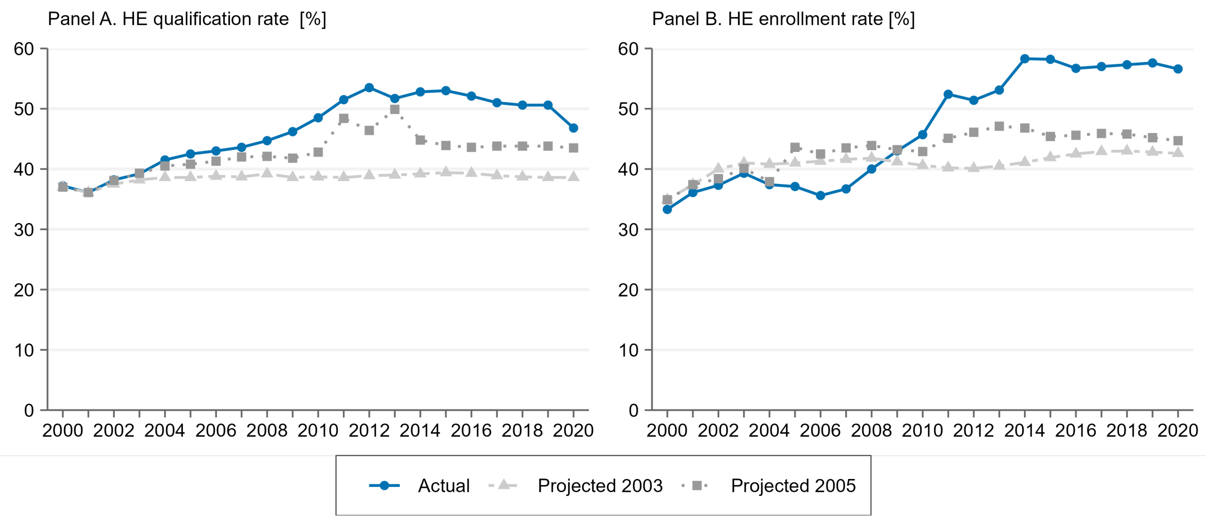
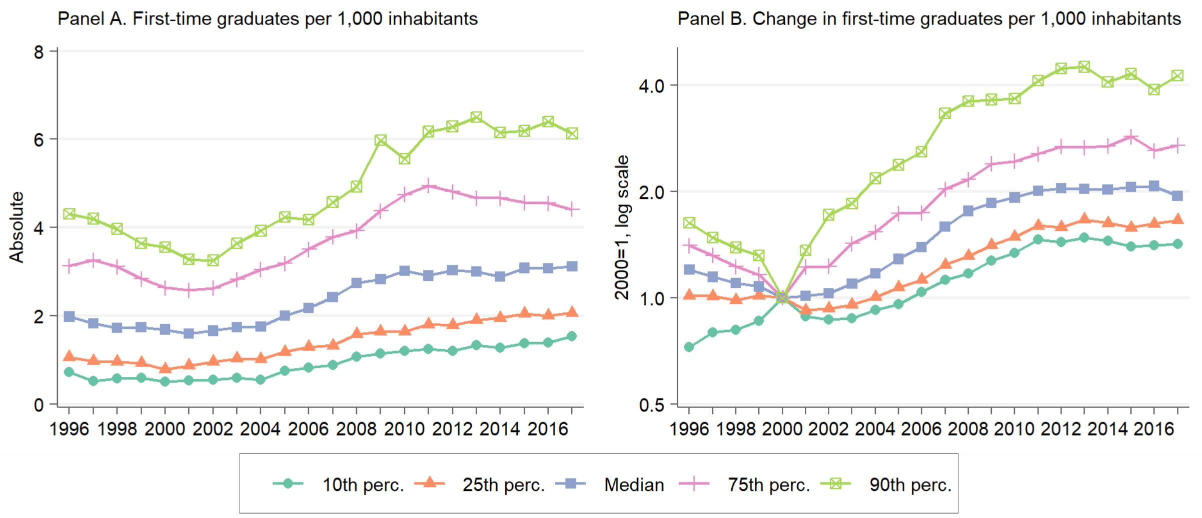
Figures and Tables

Figure 1: HE qualification and enrollment rate – actual vs. projected



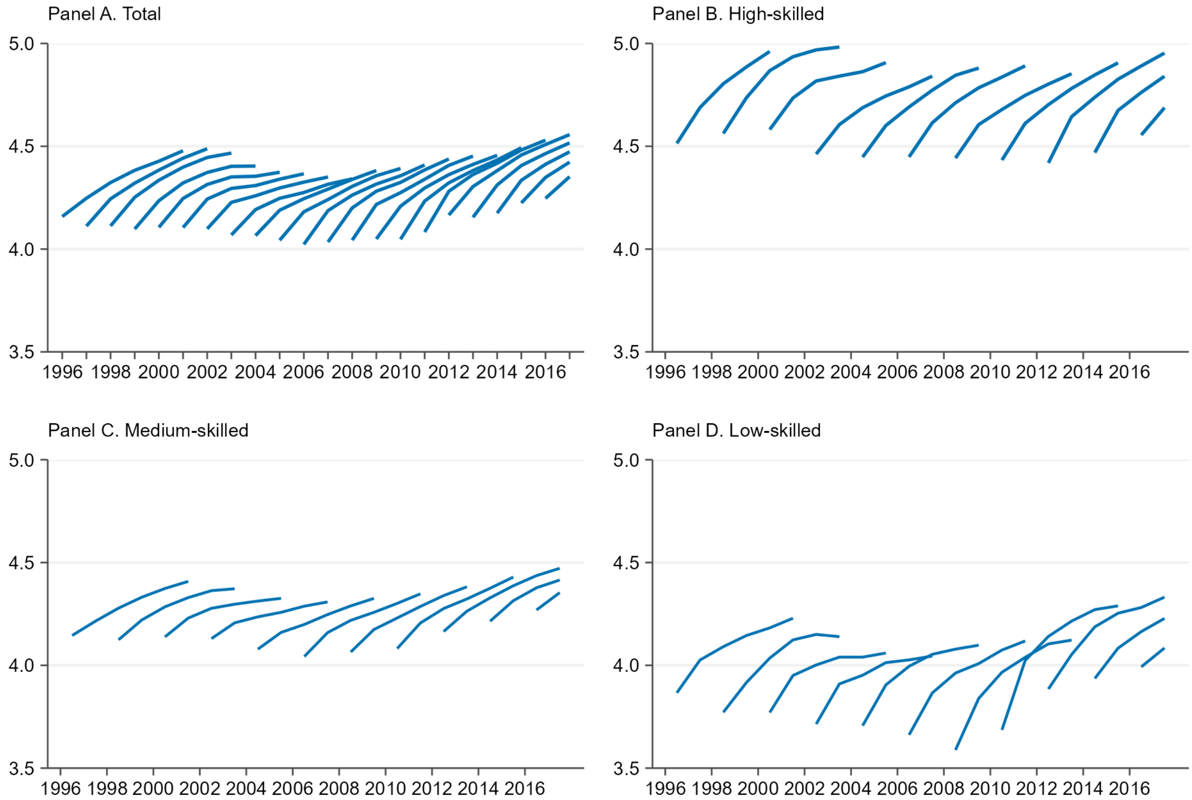
Notes: The figure shows the evolution of the share of school leavers qualified to enter HE and the share of students in their first semester (first enrollment), respectively, in the age-specific population. The data source for actual rates is the Federal Statistical Office of Germany (BMBF, 2023), for projected rates the KMK (2003, 2005).

Figure 2: HE expansion rate by quantile of regions



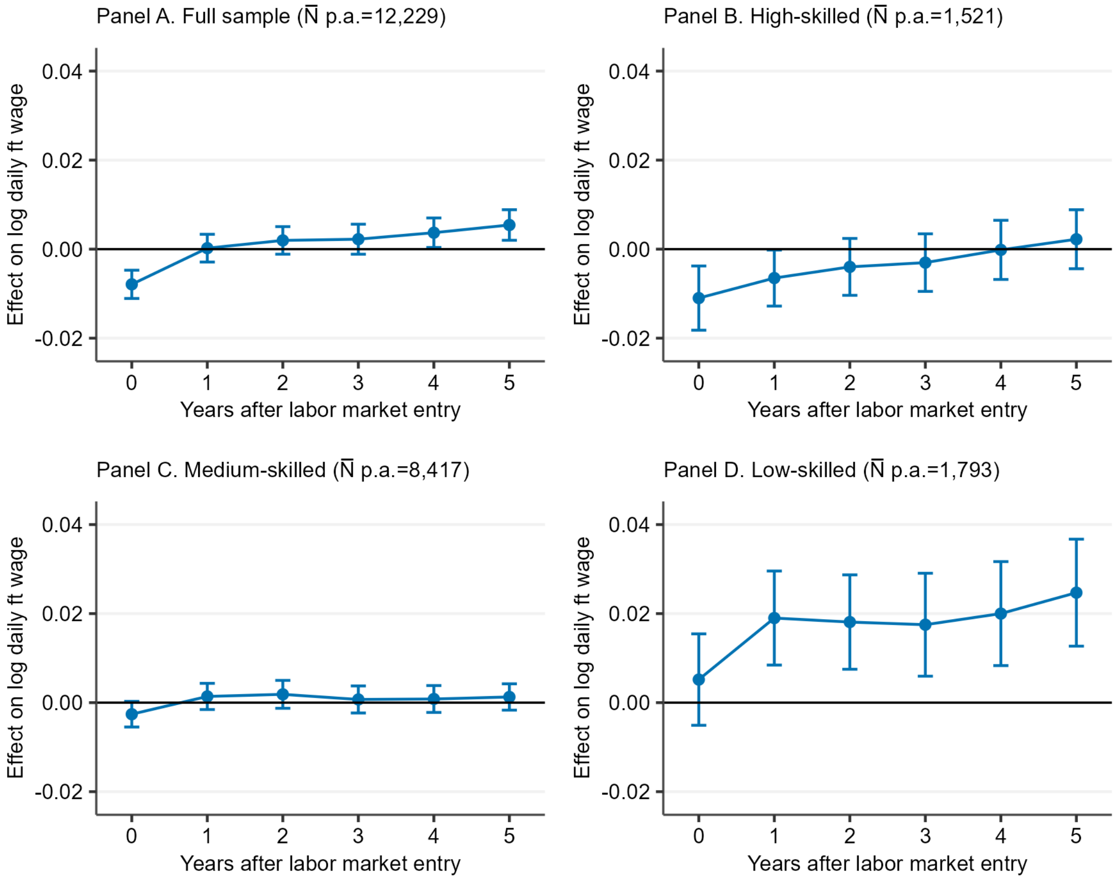
Notes: The figure shows the HE expansion rate, measured as the number of first-time graduates per 1,000 inhabitants, in absolute terms (Panel A) and as changes relative to 2000 (Panel B) by quantile of labor market region. The changes displayed in Panel B are normalized to 1 in 2000 and presented in log scale. Only regions with 50 or more first-time graduates in 2000 included. First-time graduates are defined as all graduates from universities and universities of applied sciences (UAS) with a BA or former university or UAS degree. Own calculation based on data from the *Statistics of Examinations* from Destatis (Destatis, 2018b) .

Figure 3: Wage profiles by labor market entry cohorts



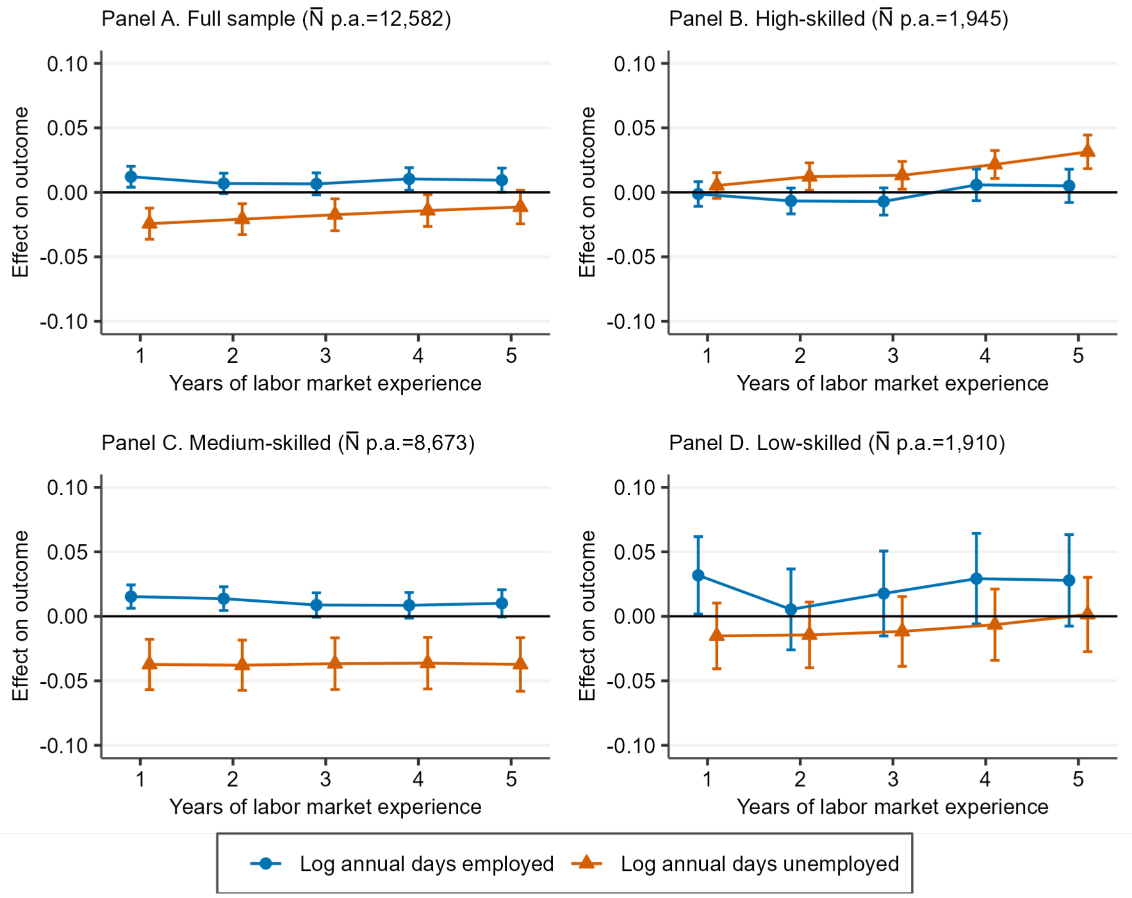
Notes: The figure shows the log real daily wage of labor market entrants (full-time employed only) by year of labor market entry and by skill group. The blue lines connect the mean outcomes from zero to five years of labor market experience for each of the entry cohorts. Skill subgroups are binned into 2-year cohorts to increase sample size. Own calculation based on the weakly anonymous Sample of Integrated Labor Market Biographies (SIAB) 1975 - 2017.

Figure 4: Experience-specific effect of the HE expansion rate on daily wages of full-time workers by skill groups



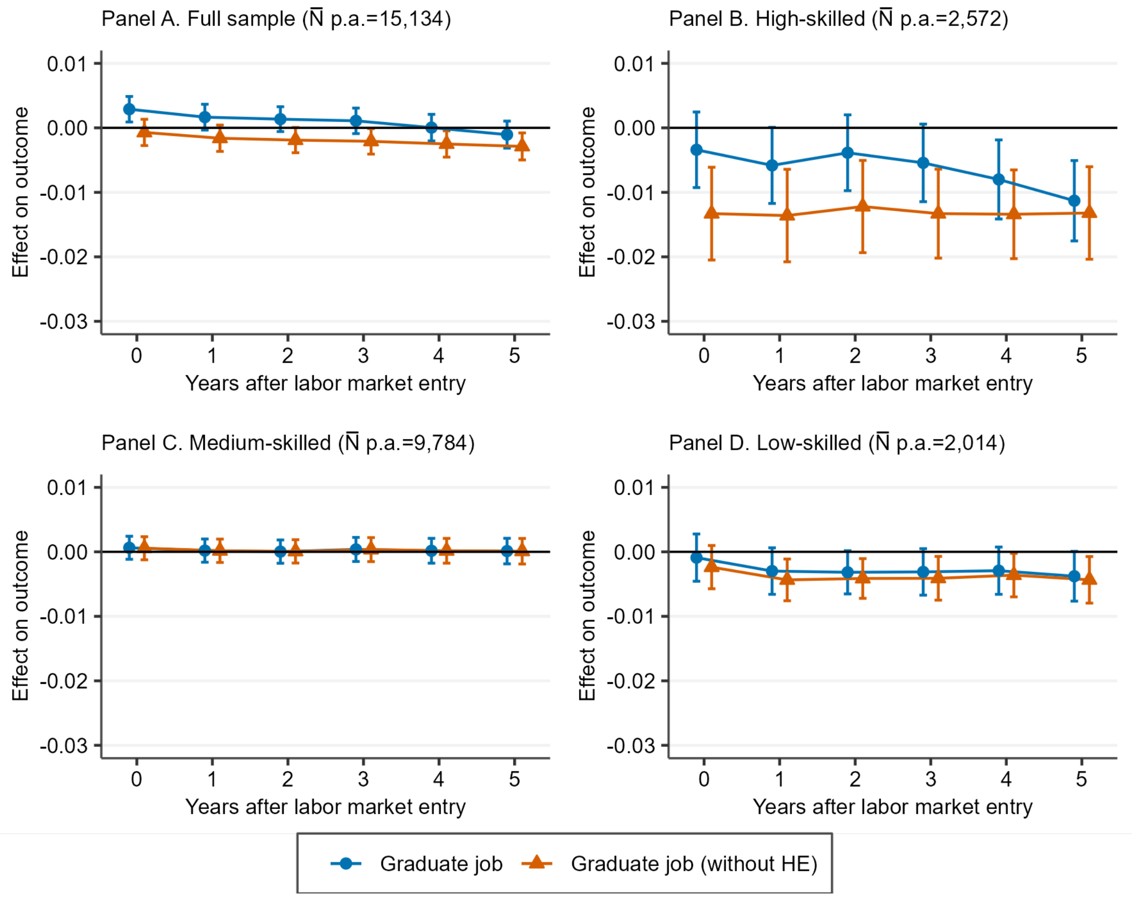
Notes: The figure plots the β_e coefficients from estimating equation (1), using log daily wages of full-time workers as the outcome variable. All models include region, cohort, calendar year, and experience year fixed effects and the unemployment rate as controls. The sample size in brackets in the panel header refers to the average total number of labor market entrants per year collapsed into region-year cells. 95 percent confidence intervals shown. Robust standard errors clustered at the cohort×region-level.

Figure 5: Experience-specific effect of the HE expansion rate on (un-)employment by skill groups



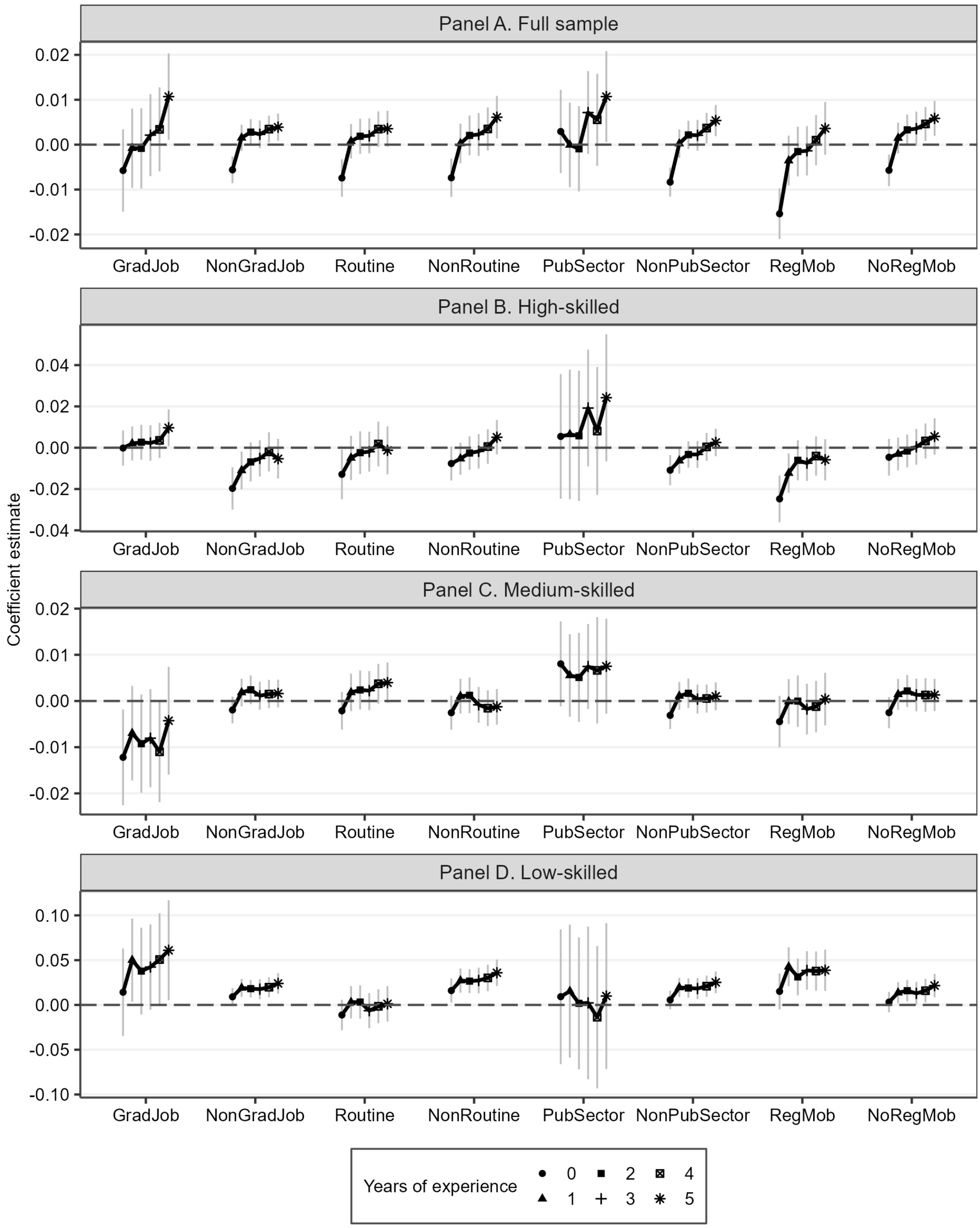
Notes: The figure plots the β_e coefficients from estimating equation (1), using the log number of days employed subject to social security contributions and the log number of days unemployed per experience year as outcome variables. All models include region, cohort, calendar year, and experience year fixed effects and the unemployment rate as controls. The sample size in brackets in the panel header refers to the average total number of labor market entrants per year collapsed into region-year cells. 95 percent confidence intervals shown. Robust standard errors clustered at the cohort$\times$region-level.

Figure 6: Experience-specific effect of the HE expansion rate on employment in graduate jobs



Notes: The figure plots the β_e coefficients from estimating equation (1), using as outcome variables the probability of being employed in a graduate job and in a graduate job excluding the higher education sector. All models include region, cohort, calendar year, and experience year fixed effects and the unemployment rate as controls. The sample size in brackets in the panel header refers to the average total number of labor market entrants per year collapsed into region-year cells. 95 percent confidence intervals shown. Robust standard errors clustered at the cohort×region-level.

Figure 7: Effect heterogeneity



Notes: The figure plots the β_e coefficients from estimating equation (1) for different subgroups, using log daily wages of full-time workers as the outcome variable. The coefficients represent the effect of the HE expansion rate in the respective skill group (panels) varying by years of labor market experience (points). Different subsamples are presented on the x-axis and are based on entry characteristics (see text for details). All models include region, cohort, calendar year, and experience year fixed effects and the unemployment rate as controls. 95 percent confidence intervals shown. Robust standard errors clustered at the cohort×region-level.

Early Career Effects of Entering the Labor Market During Higher Education Expansion

Johannes Goehausen* Stephan L. Thomsen†

Online Appendix

February 27, 2025

Contents

A Additional Descriptive Patterns **A1**

B Theoretical Predictions about the Effect of Higher Education Expansion **A6**

C Data Details **A9**
C.1 Statistics of Examinations A9
C.2 SIAB Data Preparation A9
C.3 Sample Restrictions A10
C.4 Construction of Outcome Variables A11

D Plausibility Checks and IV Approach **A18**
D.1 IV Approach A18
D.2 IV Results A19

E Additional Regression Results **A28**

F Robustness Checks **A38**

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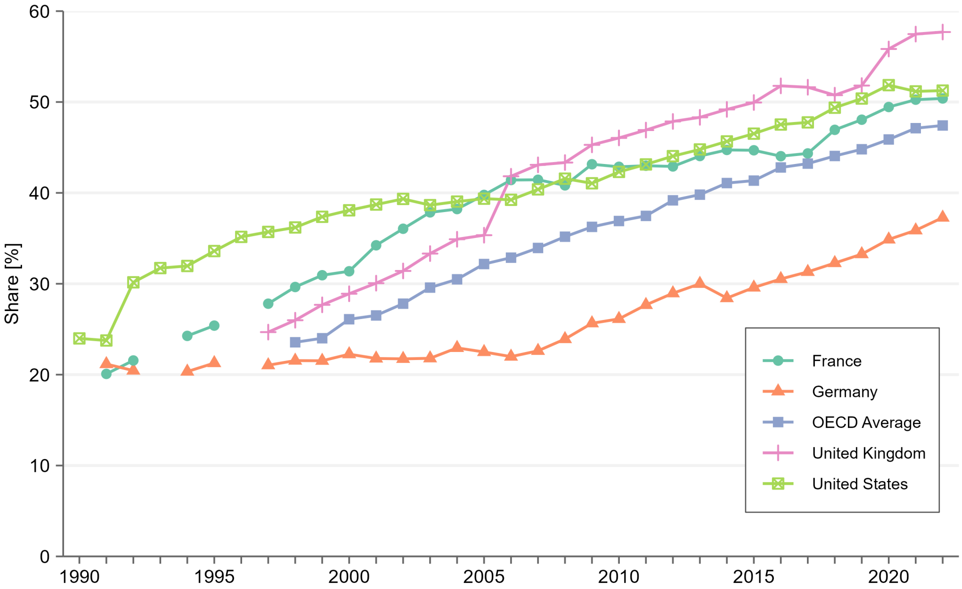
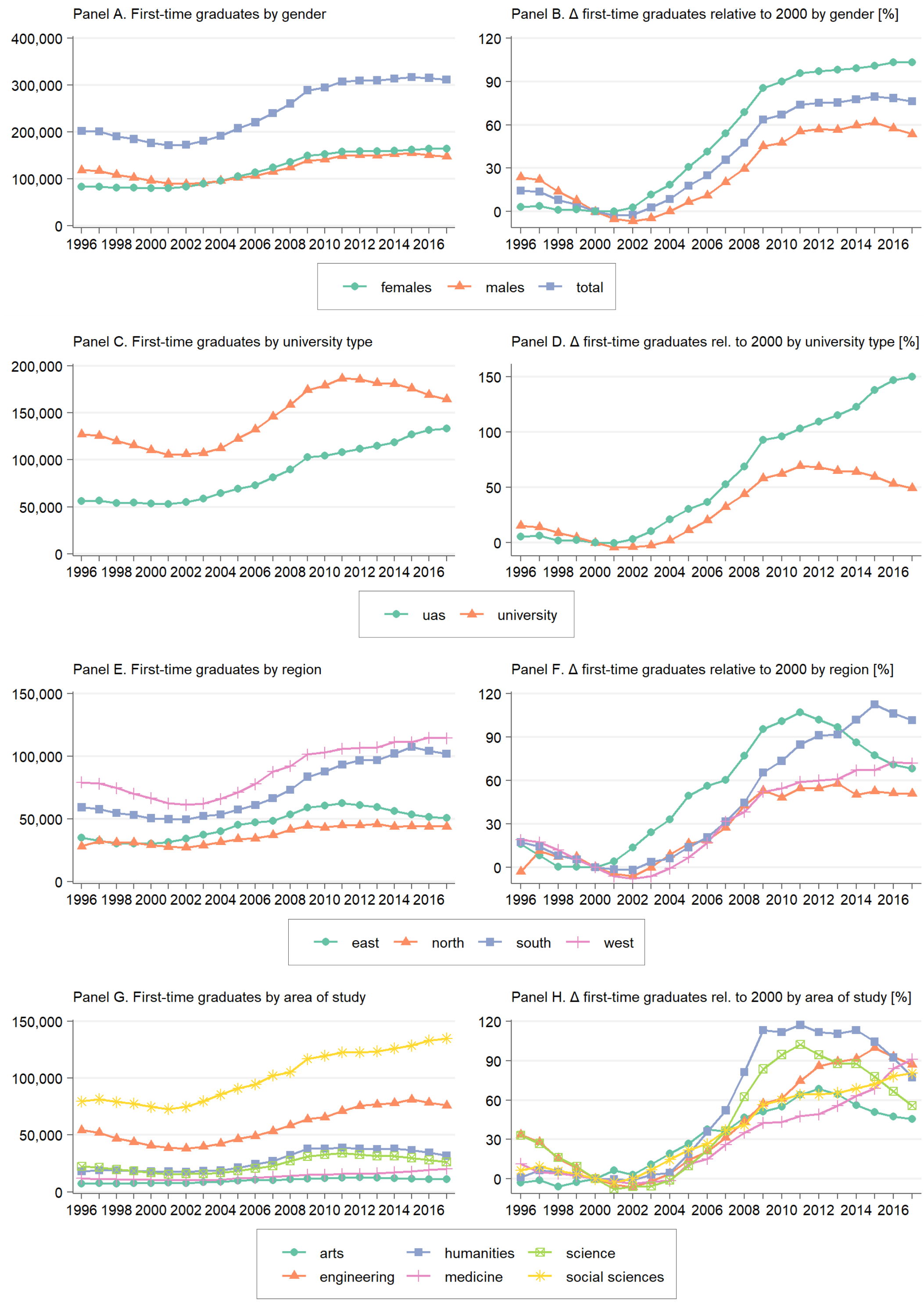
A Additional Descriptive Patterns

Figure A-1: Share of the population aged 25 to 34 years with tertiary education across selected OECD countries



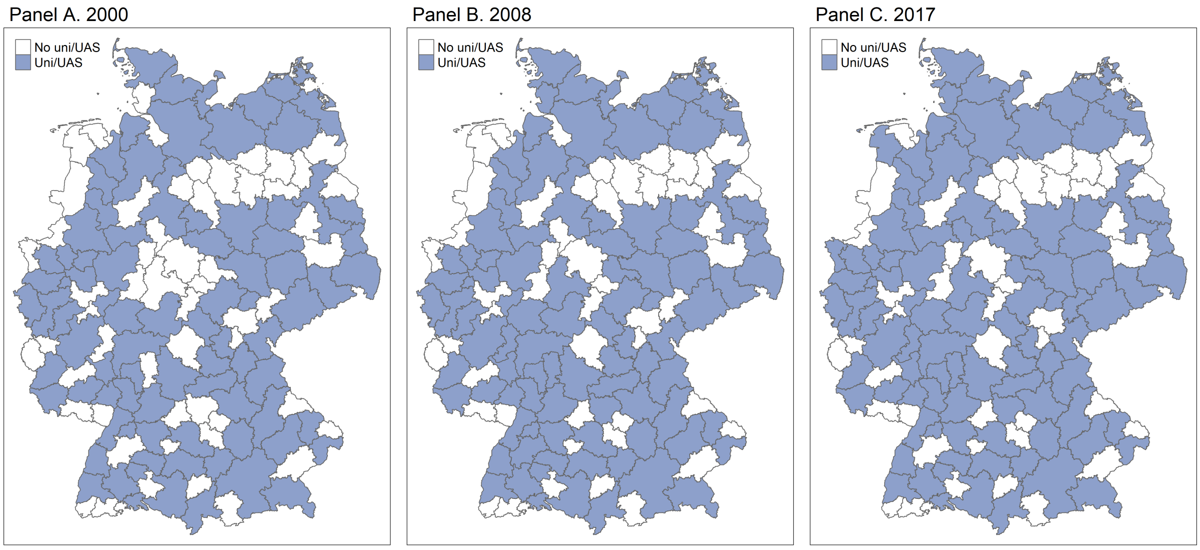
Notes: The figure shows the development of the share of the population aged 25 to 34 years with a tertiary education degree in selected OECD countries. Gaps in the time series are due to missing observations. The data source is OECD (2023).

Figure A-2: HE expansion in Germany by subgroups



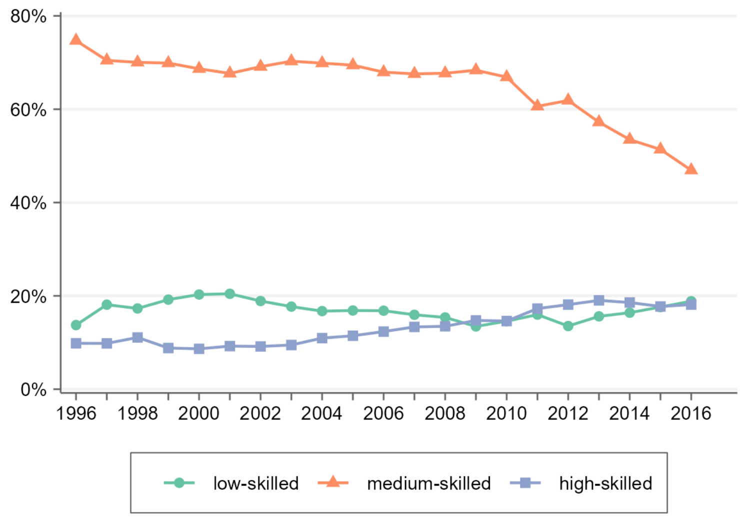
Notes: The figure shows the total number of first-time graduates in absolute terms and as percentage changes relative to 2000 for different subgroups: gender (Panels A-B), type of institution (Panels C-D), broad geographic region (Panels E-F), and areas of study (Panels G-H). UAS stands for universities of applied sciences. East is defined as colleges located in East Germany, West as North Rhine-Westphalia, Rhineland-Palatinate, Hesse, and Saarland, North as Schleswig-Holstein, Bremen, Hamburg, and Lower Saxony, and South as Baden-Wurttemberg and Bavaria. The areas of study "agricultural, forestry and food sciences, veterinary medicine", "sports", and "other subject or unclear" are not shown in Panels G-H. The data source is the ICE database of science and education departments in the state ministries (DZHW: ICEland dataset stock numbers 35801 and 35901; data basis: special evaluation of the Federal Statistical Office of Germany).

Figure A-3: University regions



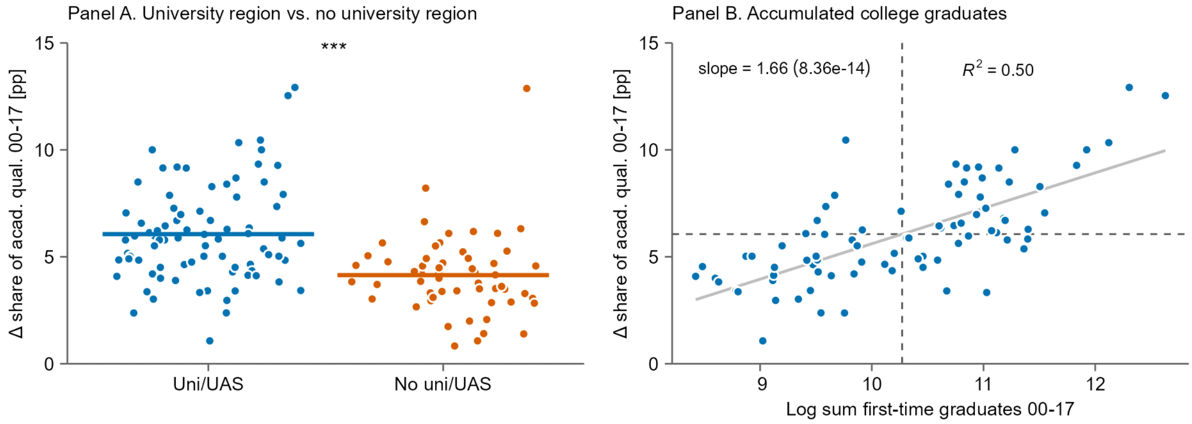
Notes: The figure shows the spatial distribution of university regions in Germany for selected years. University regions are defined as labor market regions with more than 50 first-time graduates from universities or universities of applied sciences in the respective year. Labor market regions are defined according to Kosfeld and Werner (2012). Own calculation based on data from the *Statistics of Examinations* from Destatis (Destatis, 2018). Geodata are derived from GeoBasis-DE/BKG (2018).

Figure A-4: Skill composition of labor market entrants



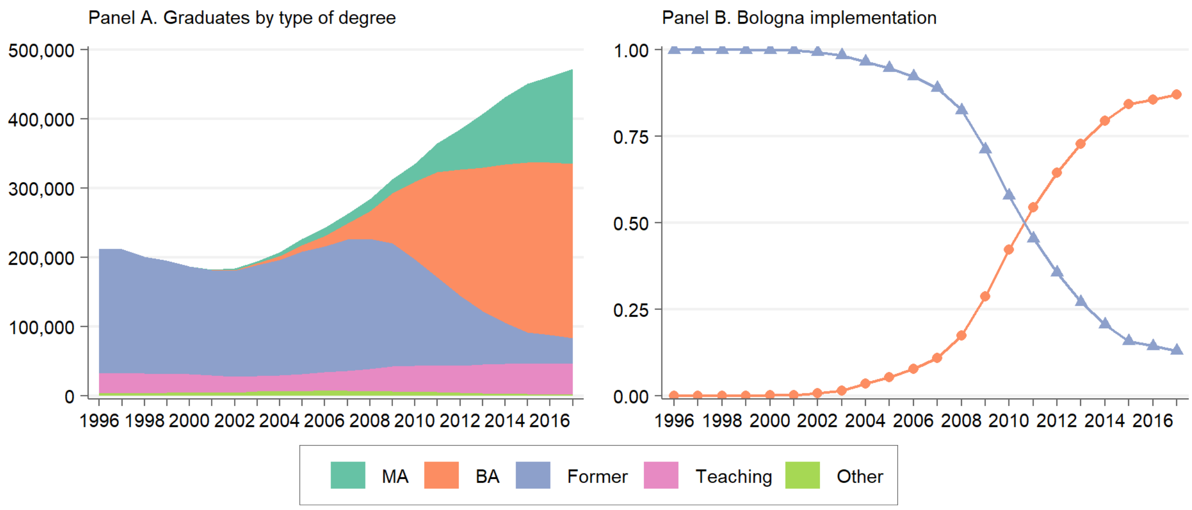
Notes: The figure shows the skill composition of labor market entrants in percent. Own calculation based on the weakly anonymous Sample of Integrated Labor Market Biographies (SIAB) 1975 - 2017.

Figure A-5: Linking college presence and HE expansion to regional skill supply



Notes: The figure shows correlations between the presence of universities (x-axis, Panel A) respectively the cumulative sum of first-time graduates (x-axis, Panel B) and the change in the share of employees with a tertiary degree (y-axis) over the period from 2000 to 2017. Panel A uses all 141 regional labor markets, Panel B only university regions. The stars in Panel A represent the result of a Wilcoxon test for group mean comparison. The gray solid line in Panel B represents a trend line resulting from a linear fit, with the respective slope and R-squared values noted above; the dashed lines represent the respective means. Own calculations based on from the *Statistics of Examinations* (Destatis, 2018) and the Regional Database of Destatis (Destatis, 2019).

Figure A-6: First-time graduates by type of degree



Notes: The figure shows the number of college graduates by type of degree (Panel A), excluding doctoral degrees. "Former" refers to degrees from universities and UAS that were offered before the Bologna Process, such as the *Diplom* or *Magister*. "Teaching" degrees include BA and MA teaching degrees. "Other" degrees consist of all degrees not included, such as art degrees. Panel B refers to the Bologna implementation and shows the share of BA graduates among graduates with BA or former university or UAS degrees. Own calculation based on special evaluations from Destatis and DZHW: ICEland data stock 35801.

Table A-1: Personnel and financial resources

Year	Ft graduates per		Current expend.	Academic staff funded by		
	professor	staff	per ft graduate	Basic	*Hochschulpakt*	Third party
1996	5.375	1.308	-	-	-	-
1997	5.338	1.307	-	-	-	-
1998	5.073	1.226	-	-	-	-
1999	4.872	1.180	-	-	-	-
2000	4.674	1.124	-	-	-	-
2001	4.559	1.071	0.148	-	-	-
2002	4.559	1.050	0.157	-	-	-
2003	4.782	1.093	0.151	-	-	-
2004	4.989	1.164	0.144	-	-	-
2005	5.491	1.255	0.135	118,975	0	42,325
2006	5.857	1.305	0.134	117,865	0	47,060
2007	6.309	1.371	0.128	116,935	0	52,730
2008	6.755	1.410	0.125	115,675	0	59,115
2009	7.192	1.454	0.120	121,115	0	67,465
2010	7.112	1.401	0.125	122,925	2,455	73,460
2011	7.158	1.412	0.126	124,635	3,865	80,200
2012	7.059	1.375	0.130	122,765	7,145	85,920
2013	6.884	1.328	0.137	124,605	12,665	89,450
2014	6.859	1.328	0.141	123,815	16,370	91,330
2015	6.842	1.326	0.144	126,505	18,145	92,100
2016	6.729	1.300	0.151	132,545	21,475	92,775
2017	6.547	1.248	0.159	134,965	22,795	96,195

Notes: The table shows indicators of personnel and financial resources of universities. Ft graduates stands for first-time graduates. Full-time academic and creative arts staff only. The *Hochschulpakt* (Higher Education Pact) refers to the additional resources provided by the federal and state governments to cope with the high student numbers during the period 2007 to 2020. No data available for years marked with -. Own calculation based on special evaluations from Destatis (Fachserie 11 Reihe 4.4, Fachserie 11 Reihe 4.5) and special evaluations from Destatis and DZHW: ICEland data stocks 35801 and 60002.

B Theoretical Predictions about the Effect of Higher Education Expansion

According to *human capital theory* (Becker, 1964; Mincer, 1974), education increases the productivity of workers and thus their wages. In contrast, the *positional value theory* (Thurow, 1975) argues that individuals' labor market returns depend on the relative rather than the absolute value of their acquired skills. Job seekers are ranked by employers based on their signaled skills and hired accordingly, i.e., they are rewarded based on their position in the labor queue. Since job seekers are not fully mobile and firms' job offers have specific qualification requirements, the length of the labor queue can vary across regional labor markets as well as across age, skill, and occupational groups. This reasoning implies that the value of education is cohort-, location- and job-specific. Applied to the HE expansion, we would expect diminishing returns during HE expansion, as the average labor market entrant in a skill group is initially ranked down in the labor queue and receives job offers of lower quality. In contrast to the adverse effects in a typical recession, this does not result from a change in the overall wage offer distribution, but from a shift in the skill distribution of labor supply. The discussed implications of the positional value theory are relatively similar to those of the *cohort crowding hypothesis*, which is grounded in neoclassical theory (see for an early review Korenman and Neumark 2000). It posits that an increase in the relative cohort size puts downward pressure on wages and leads workers to reduce their search efforts and to reduce their employment. There is an extensive literature providing empirical support for this hypothesis—either focusing on demographically driven changes in cohort size across age groups (e.g., Shimer, 2001; Brunello, 2010) or on changes in cohort size across age and skill groups (e.g., Card and Lemieux, 2001; Biagi and Lucifora, 2008; Glitz and Wissmann, 2021).

An alternative implication arises from *labor market institutions.* Compared to the US, the German labor market is relatively rigid. Wage levels, wage structures, and working conditions are often subject to collective bargaining agreements. Although declining in relevance, this still applies to about four in ten employees in 2019 (compared to seven in ten employees in 1996) (Kohaut and Hohendanner, 2023). Since collective bargaining agreements have an average term of 25 months (WSI, 2020), labor market adjustments to relative supply changes occur only with a certain delay, if at all. Hence, in the case of

HE expansion, we would expect no initial wage effects in a fully rigid labor market, given that nominal wage cuts in collective bargaining agreements are very unlikely. Potential effects then manifest only in employment changes. Over time, wage hikes could also be passed on more slowly or to a lesser extent.

However, these theories are all supply-side or institutionally oriented and implicitly assume that labor demand is exogenous and firms do not respond to the changes in skill supply (beyond wages). In contrast, the *skill-biased technological change* (SBTC) hypothesis focuses more on the demand side: New technologies are complementary to the use of high-skilled workers, so that the demand for college-educated workers increases more than their supply, causing the college wage premium to rise (Katz and Murphy, 1992; Goldin and Katz, 2009; Acemoglu and Autor, 2011). Applied to our case, we would predict that the HE expansion leads to wage growth at the upper end of the skill distribution, if the supply of more HE graduates leads firms to invest into skill-intensive technologies. Compared to the supply effects above, this technology effect should affect all age groups within a skill group. In the extended model of *routine-biased technological change* (RBTC), it is non-routine tasks, mainly performed by both low- and high-skilled workers, that are complementary to technological change, while routine tasks, mainly performed by medium-skilled workers, are substituted, leading to job polarization and increasing wage inequality (Autor et al., 2003). Analogously, we would expect wage growth for workers in non-routine-intensive jobs.

Finally, there are a couple of theories useful for explaining the persistence of initial wage effects.[1] According to *search theory* (Topel and Ward, 1992), job mobility is a crucial vehicle for wage growth in general and for recovery from shocks experienced at labor market entry in particular. Therefore, we would expect a higher search intensity for higher paying or better-matching jobs during the early career phase for those who experience an initial downgrading due to the higher skill supply. However, if the HE expansion affects not only the initial job placement but also the job search and matching process later on (e.g., due to the higher skill level in subsequent cohorts), the initial lock-in effects could be even stronger. In a similar vein, *assortative matching* (Gibbons et al., 2005) implies that there is a gradual learning process of firms about the true productivity

[1] Oreopoulos et al. (2012) discuss these theories in detail in the case of recessions.

of workers. Regardless of their initial job queue placement, firms should retain or promote those with higher ability.

Altogether, the theoretical frameworks discussed differ in their predictions about the effect of the HE expansion in Germany, ranging from negative over zero to positive effects for wages of high-skilled workers. Isolation of the actual effects is therefore an empirical question as they depend simultaneously on (at least) i) the size and speed of the skill supply shock, ii) the response of firms in terms of technology investment, iii) the substitutability with lower qualified workers, iv) labor market frictions, and v) the efficiency of the matching process.

C Data Details

C.1 Statistics of Examinations

The *Statistics of Examinations* is an administrative data set on all final examinations passed at publicly acknowledged HE institutions in Germany, collected by the Federal Statistical Office of Germany (Destatis, 2018). The microdata are available on application and through its Research Data Center. However, we use the freely available, aggregated data published in the annual reports "*Prüfungen an Hochschulen*". For each year of our observation period, we extracted the number of graduates per HE institution (table *"2 Exams passed by type of HE institution, most recently attended HE institution and summarized types of final exams"*). The names of the institutions were harmonized and the institutions were assigned to one of the 401 districts in Germany (delineation as of 2017) and then to labor market regions by using the address of their main location. As explained in detail in the text, our analysis focuses only on universities and universities of applied sciences (UAS).

C.2 SIAB Data Preparation

To prepare the SIAB data for analysis, we closely follow the guidelines provided by the FDZ of the IAB (Dauth and Eppelsheimer, 2020). The most important steps are briefly described below.

a) Categorization of the Educational Attainment Variable

To divide workers into skill groups, we use the variable "professional training (imputed)" that offers a correction for missing values and inconsistencies that occur in the original variable. The imputation procedure is described in Thomsen et al. (2018) and is based on the procedure IP1 proposed by Fitzenberger et al. (2006). This imputation exploits the panel structure of the data to infer a plausible educational status at each point in time. First, education information is extrapolated to subsequent spells with missing or lower levels of education (forward extrapolation). Then, education information from the first spell with non-missing information is extrapolated to previous spells with missing information up to a certain minimum age (backward extrapolation). Following previous related studies (e.g., Antonczyk et al., 2010; Dustmann and Glitz, 2015), we split employees into three different skill groups: low-skilled (i.e., without vocational training), medium-skilled (i.e., completed vocational training) and high-skilled (i.e., degrees from a university or UAS).

b) Imputation of Censored Wages

Since reporting is mandatory and employers face penalties in cases of mis- or non-reporting, the data on employment biographies (status and dates of employment, wages, etc.) are highly reliable. However, for administrative reasons, wage information is only relevant up to the contribution assessment ceiling, which varies by region and year (e.g., 76,200 euros per year in West Germany, and 68,400 euros per year in East Germany in 2017). Therefore, wages are top-coded at the respective threshold value. Since we focus on the wages of labor market entrants, top-coded wages are likely to have only a small impact on our analysis. Nevertheless, we impute them by following the two-step procedure used by Dauth and Eppelsheimer (2020). Another threshold is the marginal earnings threshold for part-time employees. Jobs with wages below this threshold are either exempt from social security contributions (before 1999) or subject to a lump-sum contribution payable by the employer (1999 or later). These jobs are only included in the data from 1999 onwards. We mark wages below the marginal part-time earnings threshold as "marginal". Finally, wages are deflated by the yearly consumer price index (base year = 2015) published by Destatis (2021).

C.3 Sample Restrictions

Following common practice, we exclude spells from sources other than the Employment History (BEH), the Benefit Recipient History (LeH), and the Unemployment Benefit II Recipient History (LHG) that cover the universe of employment and unemployment spells. We further restrict the spell data to the main episode, which is defined as the job with the highest wage.

Labor market entry is defined as the first day of employment subject to social security contributions, excluding entries into vocational training. To avoid interrupted career paths, we also exclude those entries where an apprenticeship is started within five years. To remove individuals who have died, left the country, or dropped out of the labor force completely, we count only those labor market entrants who are observable in at least one other period (in addition to the labor market entry). Moreover, we restrict the sample to those who enter the labor market during our observation period from 1996 to 2015 and follow them through their first five years of work experience. Since the version of the SIAB we use only extends to 2017, our sample is right-censored, i.e., 2012 is the last cohort we can observe for the full five years of experience (see also Appendix Table C-2). To exclude atypical employment biographies, we drop those who enter the labor market younger than 16 and older than 30 years. In addition, workers with missing information on their place of work are dropped.

C.4 Construction of Outcome Variables

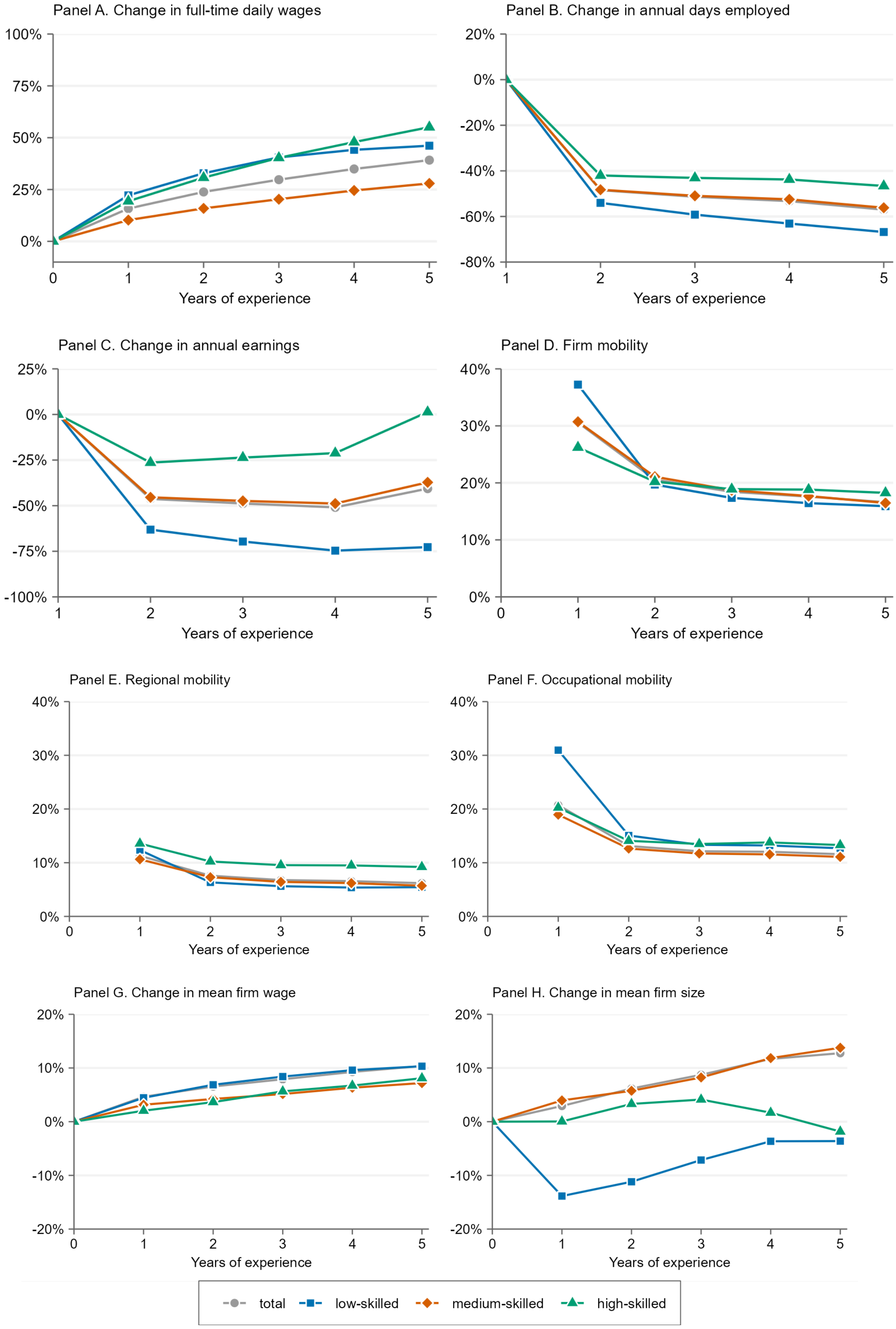
The SIAB contains detailed wage and employment information on employees, which we exploit to construct our outcome variables. First, we use the *log daily wage* of the main employment spell at the respective cut-off date. The daily wage is calculated in the SIAB from the total pay that is reported by the employer for a given period and the duration of that period in calendar days. To rule out changes in working hours per day, we use the *log full-time daily wage* as the main outcome variable. For zero years of experience, this gives the exact entry wage; for one year of experience, the exact wage one year after labor market entry, and so on. Second, we construct employment measures as the sum of all days in employment per experience year. *Log annual days employed* give the length of all spells in the Employment History (BEH) and subject to social security contributions in calendar days per experience year, while *log annual days unemployed* give the length of all spells with benefit receipt from the Benefit Recipient History (LeH) in calendar days per experience year. In addition, we use the different employment statuses (*employed*, *unemployed*, and *out of SIAB*) and employment in specific sectors or jobs (higher education system, non-graduate job) as dummy variables. Third, we consider the *log annual earnings*, calculated as the sum of all labor earnings per experience year. Hence, this measure can include multiple spells of employment or (un-)employment.

Moreover, we construct four measures of job mobility. *Firm mobility* is a dummy indicating whether a labor market entrant changed his/her firm compared to the previous year. Note, that the firm is measured at the establishment level in the SIAB. *Regional mobility* is a dummy indicating whether a labor market entrant changed his/her region of workplace compared to the previous year. *Industry mobility* is a dummy indicating whether a labor market entrant changed the industry (3-digit level) of the employing firm compared to the previous year. *Occupational mobility* is a dummy indicating whether a labor market entrant changed his/her occupation (3-digit level; KldB1988) compared to the previous year. For all four mobility measures, we count mobility only if both the respective and the past firm/region/industry/occupation identifier are non-missing.

Furthermore, we use two measures to investigate employer quality. The *log average firm size* is the average number of employees of the employing firm measured on June 30. The *log average firm wage* is the average wage of all employees of the employing firm measured on June 30. Both measures are held constant within firms over our observation period, so that changes are only due to mobility and not to within-firm changes.

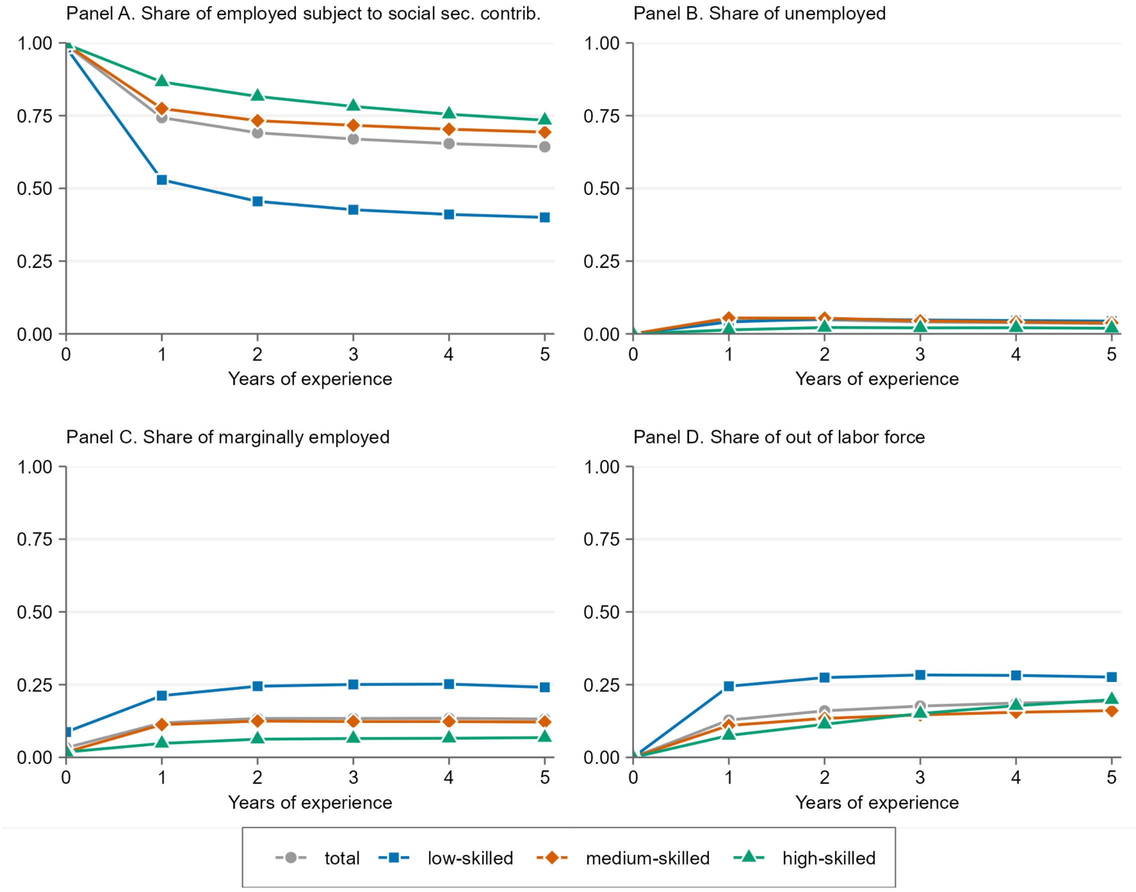
Finally, we look into the task composition of workers. We use the classification by Dengler et al. (2014) for the year 2011, which is based on an expert database (BERUFENET of the German Federal Employment Agency) and distinguishes between five tasks: analytical non-routine tasks (1), interactive non-routine tasks (2), cognitive routine tasks (3), manual routine tasks (4) and manual non-routine tasks (5). We match the share of tasks performed in each job to the SIAB data using the occupation identifier ("beruf"). Figure C-1 shows the experience profiles and Figure C-2 shows the employment status of labor market entrants by skill group. Figure C-3 presents other important developments in the labor market (job ordering, job mobility, employer quality, task composition).

Figure C-1: Experience profiles of different labor market outcomes



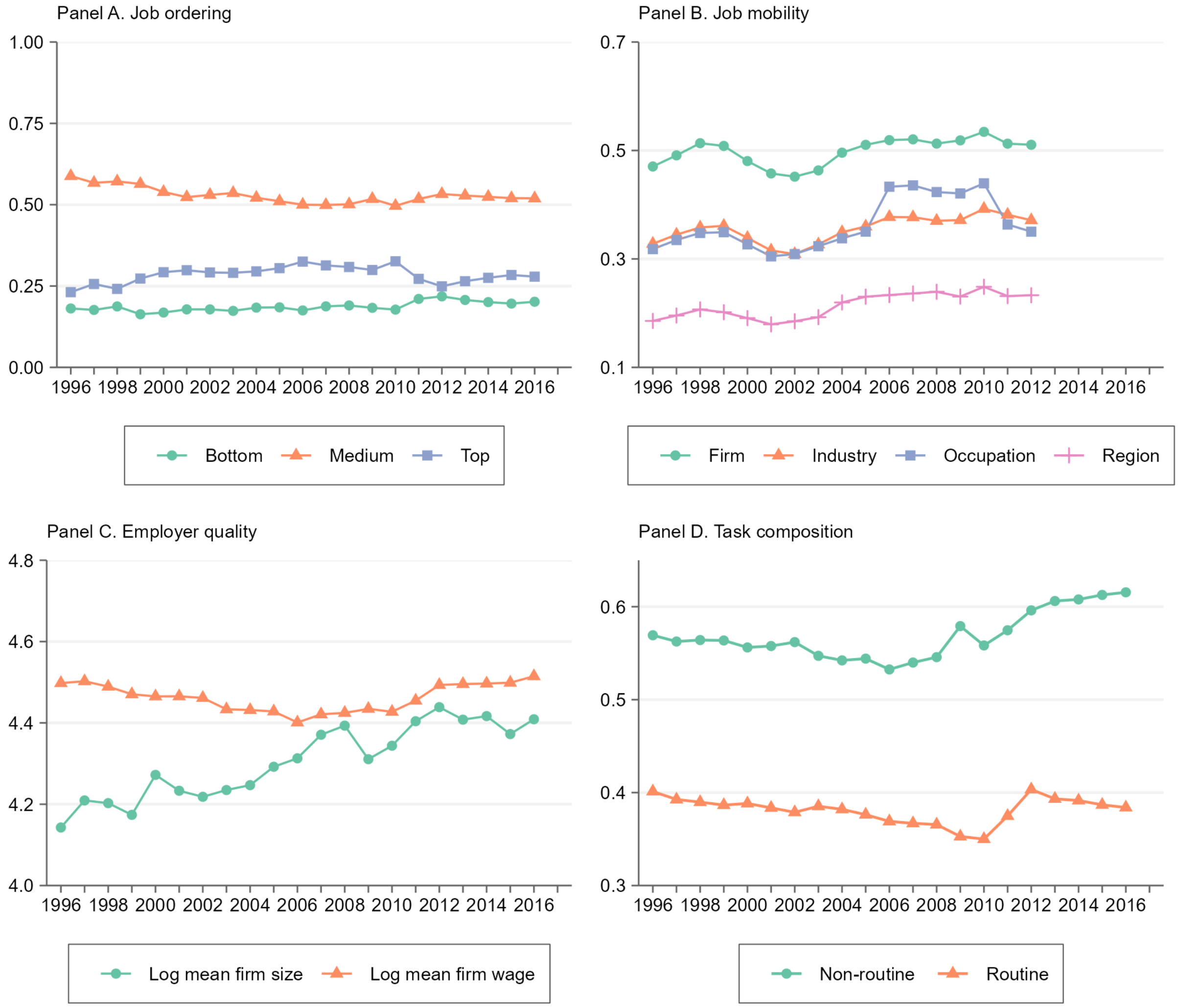
Notes: The figure shows average cross-sectional profiles of selected labor market outcomes by years of labor market experience and skill groups. Panel A shows the percentage change in real daily wages of full-time workers, Panel B the percentage change in annual days employed, Panel C the percentage change in annual earnings. Panel D shows the fraction of workers changing firms in a given experience year, Panel E the fraction changing regions of workplace, and Panel F the fraction changing occupations. Panel G shows the percentage change in mean firm wages (average per firm across observation period), Panel H the percentage change in mean firm size (average per firm across observation period). Own calculation based on the weakly anonymous Sample of Integrated Labor Market Biographies (SIAB) 1975 - 2017.

Figure C-2: Mean employment status of labor market entrants by year of labor market entry



Notes: The figure shows the mean employment status by years of labor market experience and skill groups. Panel A shows the share of labor market entrants who are employed subject to social security contributions, Panel B the share of those who are unemployed, Panel C the share of marginally employed, and Panel D those who are not observed in the SIAB, i.e., neither employed, unemployed, nor marginally employed, and thus approximately out of the labor force. Own calculation based on the weakly anonymous Sample of Integrated Labour Market Biographies (SIAB) 1975 - 2017.

Figure C-3: Job ordering, mobility, quality, and task composition by entry cohorts



Notes: The figure shows the evolution of employment characteristics by labor market entry cohorts. The year of entry is indicated on the x-axis. Job ordering is defined as the share of workers entering an occupation in the top 30 percentiles of the wage distribution (top), the share entering between the 30th and 70th percentiles (middle), and the share entering in the bottom 30 percentiles (bottom). Job mobility is defined as the share of workers who switch their firm, industry of employment, occupation, or region of workplace after five years of experience. Employer quality indicators show mean firm wage and mean firm size at labor market entry. The task composition is measured at entry according to the classification of Dengler et al. (2014) for the year 2011. The sharp increase in occupational mobility between 2006 and 2010 is due to a change in the reporting scheme corresponding with the new occupation code (KldB 2010) introduced by the Federal Employment Agency. The same is true for the simultaneous increase in the task intensity around this time. Own calculation based on the weakly anonymous Sample of Integrated Labour Market Biographies (SIAB) 1975 - 2017.

Table C-1: **Size of analysis sample by entry cohort and experience year**

Year of labor market entry	Years of experience					
	0	**1**	**2**	**3**	**4**	**5**
1996	14,211	11,550	11,069	11,351	11,410	11,250
1997	14,916	11,611	11,759	12,011	11,753	11,516
1998	15,502	12,649	12,733	12,469	12,216	12,026
1999	16,458	13,722	13,503	13,138	12,816	12,843
2000	17,084	14,018	13,652	13,182	13,126	13,307
2001	16,504	13,463	13,046	12,883	12,990	13,165
2002	14,771	12,179	11,836	11,899	11,988	11,943
2003	14,062	11,854	11,752	11,664	11,528	11,376
2004	13,268	11,645	11,331	11,053	10,831	10,778
2005	13,405	11,925	11,539	11,283	11,039	10,938
2006	14,762	13,128	12,632	12,319	12,109	12,081
2007	16,005	14,162	13,580	13,414	13,299	13,158
2008	15,637	13,689	13,295	13,116	12,965	12,934
2009	14,280	12,634	12,219	11,979	11,880	11,867
2010	15,819	14,091	13,671	13,411	13,342	13,167
2011	17,376	15,363	14,801	14,482	14,414	14,381
2012	18,338	16,554	15,970	15,555	15,358	15,126
2013	16,326	14,701	14,157	13,855	13,626	
2014	17,643	16,073	15,498	15,066		
2015	18,606	17,285	16,579			

Notes: The table shows the size of the analysis sample by entry cohort and years of labor market experience. Only labor market entrants with non-missing information on the region of labor market entry and on labor market status are shown. The sample construction is explained in detail in Appendix C.

Table C-2: Sample size by entry cohort and experience year before sample restrictions

Year of labor market entry	Years of experience					
	0	**1**	**2**	**3**	**4**	**5**
1996	16,256	11,872	11,374	11,658	11,715	11,562
1997	17,317	11,960	12,104	12,373	12,093	11,848
1998	17,653	13,056	13,133	12,841	12,589	12,389
1999	18,768	14,082	13,838	13,461	13,132	13,157
2000	19,473	14,357	13,974	13,494	13,431	13,633
2001	18,733	13,736	13,331	13,160	13,273	13,452
2002	16,790	12,462	12,099	12,161	12,244	12,200
2003	15,643	12,169	12,076	11,986	11,848	11,689
2004	14,717	11,960	11,642	11,336	11,119	11,065
2005	14,854	12,256	11,852	11,588	11,344	11,236
2006	16,315	13,424	12,910	12,587	12,379	12,357
2007	17,698	14,464	13,880	13,702	13,576	13,427
2008	17,213	13,959	13,547	13,373	13,230	13,194
2009	15,757	12,938	12,512	12,258	12,166	12,158
2010	17,334	14,381	13,945	13,680	13,627	13,440
2011	19,349	15,660	15,095	14,768	14,699	14,670
2012	20,287	16,842	16,256	15,824	15,628	15,382
2013	18,498	14,997	14,440	14,127	13,885	
2014	20,495	16,364	15,781	15,336		
2015	22,513	17,621	16,885			
2016	23,638	18,296				
2017	26,589					

Notes: The table shows the sample size by entry cohort and years of labor market experience before restricting the sample to those labor market entrants who are observable in the SIAB in at least one other year (beyond labor market entry). Only labor market entrants with non-missing information on the region of labor market entry are shown. The sample construction is explained in detail in Appendix C.

D Plausibility Checks and IV Approach

D.1 IV Approach

To address the potential endogeneity problem (see Section 4.2 in the main paper), we use an instrument variable (IV) for the HE expansion rate that is motivated by the trade literature (e.g., Card, 2001; Burstein et al., 2020) and was adapted by Ma (2024) to the context of the HE expansion in China. Although government-driven, the expansion pattern was similar to that observed in Germany in terms of regional divergence and duration. The idea of this Bartik-type or shift-share instrument is to exploit the past distribution of university sizes, which then led to differential HE expansion rates in response to common national shocks. Therefore, we construct the following instrument $x^*_{r,c}$:

$$x^*_{r,c} = \frac{HE\ enrollment_{r,1992}}{HE\ enrollment_{1992}} \times HE\ expansion_{-r,c}, \tag{1}$$

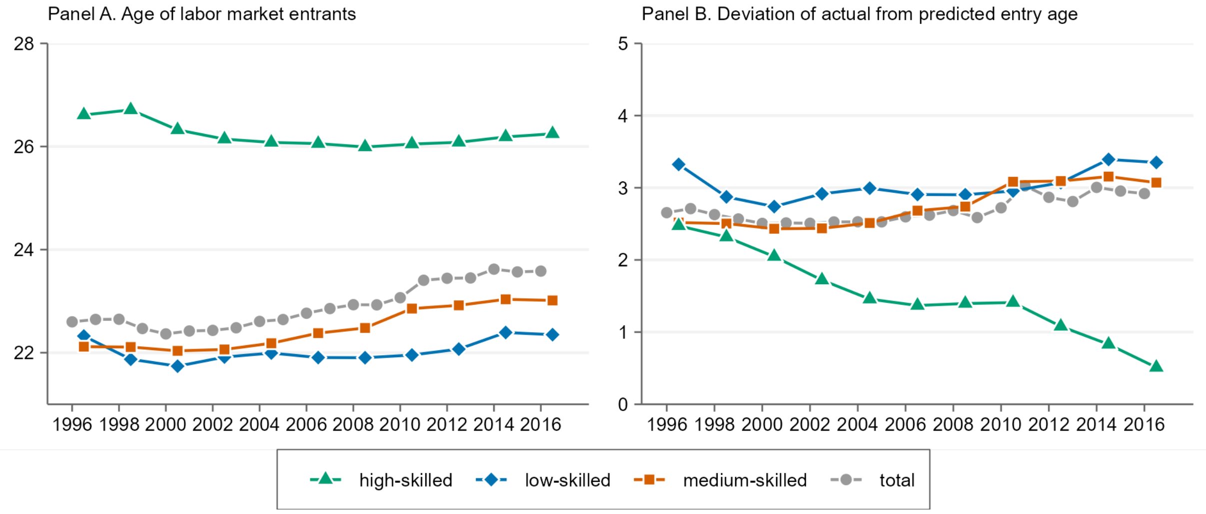
where $\frac{HE\ enrollment_{r,1992}}{HE\ enrollment_{1992}}$ represents the historical enrollment share of region r in 1992 as a proxy for university size and $HE\ expansion_{-r,c}$ the aggregate HE expansion in Germany. To lessen the endogeneity concerns, we exclude the university graduates in region r from constructing the aggregate trends (leave-one-out strategy). We use the shares in 1992, which is the earliest year for which we have enrollment data for all of Germany. As shown in Section 3.1 in the paper, the HE expansion in Germany primarily benefited regions with pre-existing universities. Indeed, the regions with the largest universities in 1992 were still the largest in 2002 (before the expansion) (see Panel A of Figure D-3). Moreover, our instrument can explain 55 percent of the variation in total HE growth (see Panel B of Figure D-3). Thus, the first-stage relationship is large and significant. Conditional on region fixed effects, we estimate a highly significant elasticity of actual university graduates to predicted university graduates of about 0.86, with a sufficiently large F-statistic (126.3; see column 1 in Table D-6). By including region fixed effects in the first stage, we control for any region-specific characteristics that are correlated with initial university enrollment shares. Although the association is reduced to 0.70 when controlling for year fixed effects, it still holds and remains highly significant (25.1; see column 2 in Table D-6). This suggests that there is sufficient regional variation in expansion patterns that deviate from secular trends in educational attainment.

The validity of the instrumental variable approach rests on the assumption that differences in past enrollment shares affect labor market entrants' outcomes solely by changing the HE expansion rate (exclusion restriction). In principle, this implies exogenous enrollment shares. We support the plausibility of this assumption in the following ways: First, the literature on evaluating the college openings in the second half of the 20$^{\text{th}}$ century (e.g., Kamhöfer et al., 2019; Berlingieri et al., 2022; Boelmann, 2024) suggests a quasi-random establishment driven by political considerations rather than economic necessities. Second, as suggested by the literature on recent advances in Bartik instruments (e.g., Goldsmith-Pinkham et al., 2020; Borusyak et al., 2022), we conduct pre-trend tests. We do so by regressing pre-expansion population and GDP growth, common proxies of regional economic development, on the initial university enrollment shares as well as on the instrumented exposure to the college expansion between 2002 and 2012 (see Figure D-4). Both local population and GDP growth in the pre-expansion period are independent of initial university enrollment shares.

D.2 IV Results

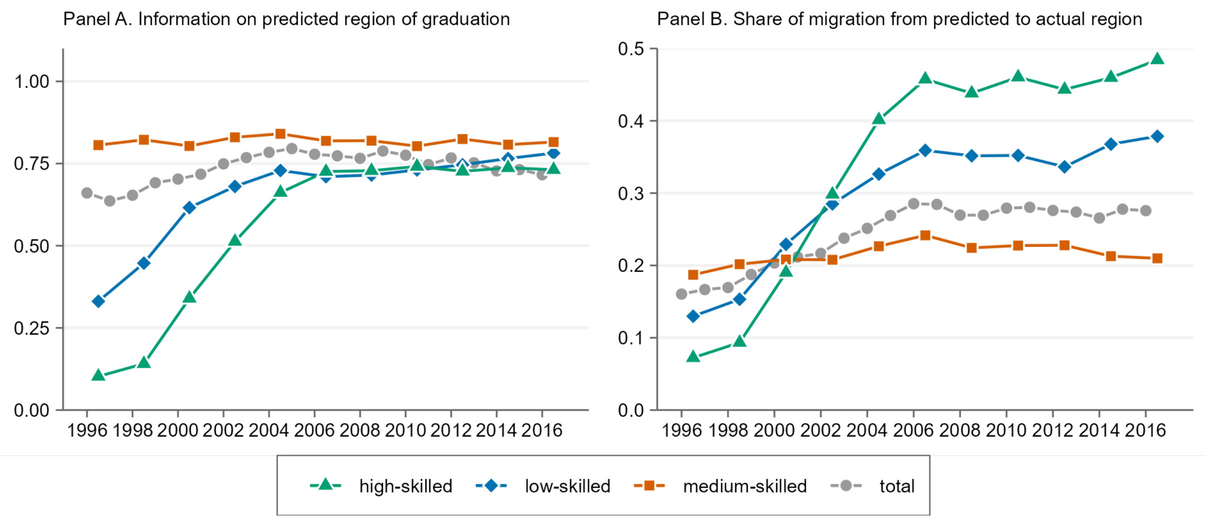
Figure D-5 compares the OLS estimates with the the IV estimates for our main result: the effect of the HE expansion rate on the log real daily wage of full-time workers, varying by year of labor market experience. The 2SLS estimates (in gray) provide qualitatively similar results to the OLS estimates (in blue), although the coefficients are pushed upwards, so that the initial wage decline is noticeably smaller and the later wage increase is slightly larger (0 years: –0.5%; 5 years: +0.6%). The downward bias in the effect could indicate either an attenuation bias due to measurement error in the HE expansion rate or a negative selection of regions into the HE expansion, consistent, for example, with students selecting into regions with high immigration of young population. However, since the differences in effect size are not too large and the confidence bands become quite wide in the second stage, we focus on the OLS estimates as our preferred estimates in the main paper.

Figure D-1: Endogeneity check: Timing of entry



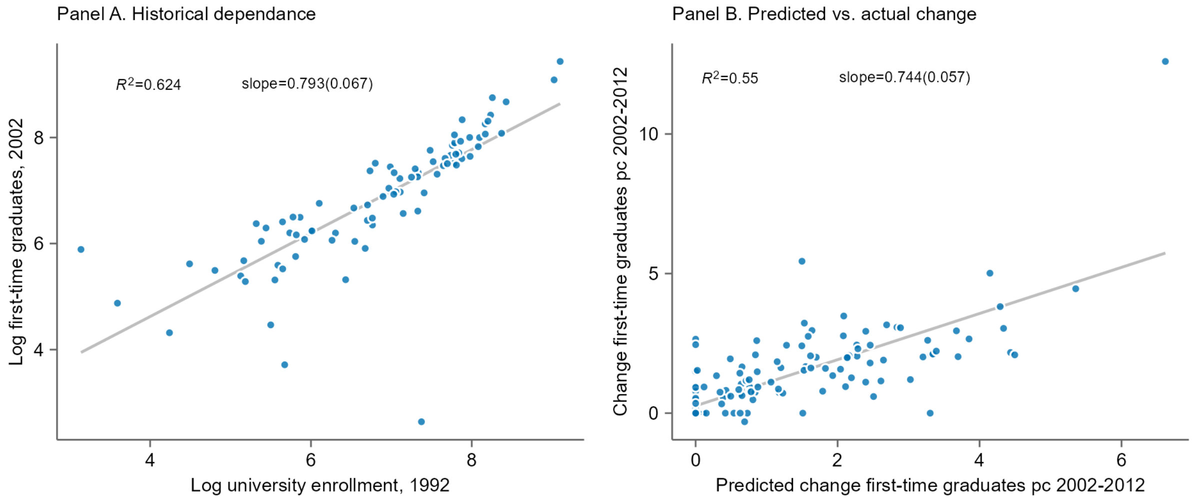
Notes: The figure shows the mean age of labor market entrants (Panel A) and the deviation of actual age from predicted age (Panel B) by skill group. The predicted age is calculated using information on birth years plus the typical length of educational programs (see text for details). Own calculation based on the weakly anonymous Sample of Integrated Labour Market Biographies (SIAB) 1975 - 2017.

Figure D-2: Endogeneity check: Migration at entry



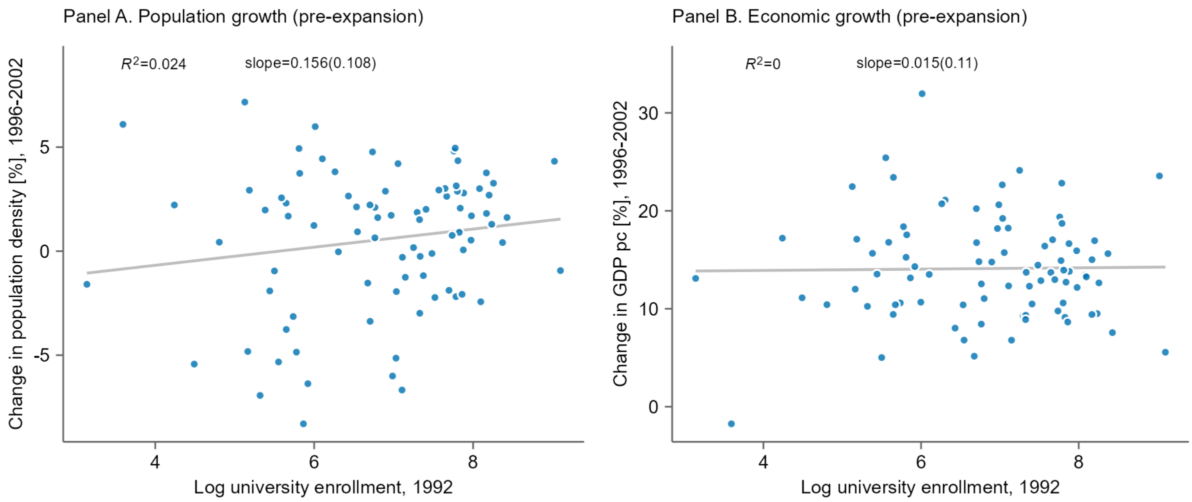
Notes: The figure shows the share of information on predicted region of graduation from school/apprenticeship/university (Panel A) and the deviation of the actual from the predicted region of entry (Panel B) by skill group. The region of graduation is predicted by using information on previous work experience (see text for details). Own calculation based on the weakly anonymous Sample of Integrated Labour Market Biographies (SIAB) 1975 - 2017.

Figure D-3: IV relevance for Bartik-type instrument



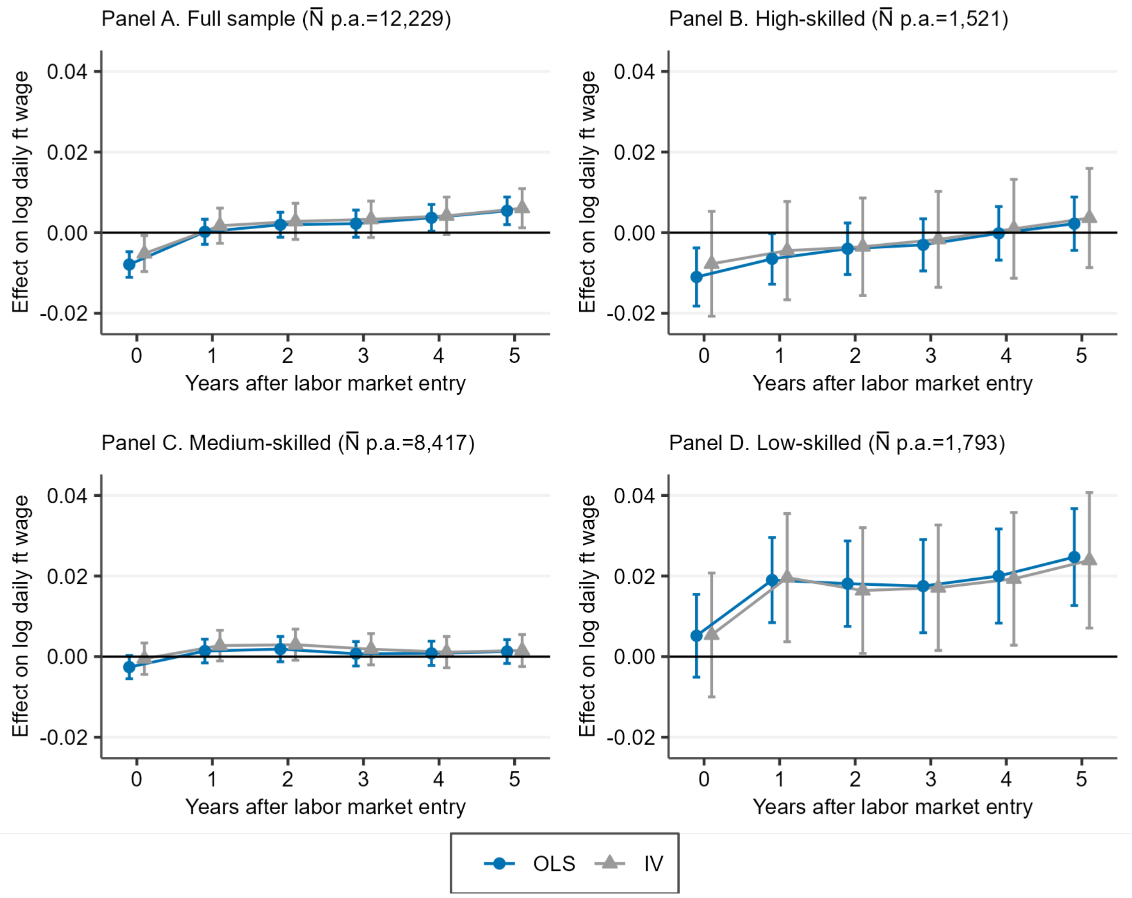
Notes: Panel A shows the correlation between the log of university enrollment in 1992 (x-axis) and the log of first-time graduates in 2002 (y-axis) at the labor market region level. Panel B shows the correlation between the change in the predicted HE expansion rate (x-axis) and the change in the actual HE expansion rate from 2002 to 2012 (y-axis). The gray solid line represents a trend line resulting from a linear fit, with the corresponding slope and R-squared noted at the top.

Figure D-4: Exogeneity checks for Bartik-type instrument



Notes: The figure shows the correlation between the distribution of university sizes (proxied log university enrollment) in 1992 (x-axis) and the change in the population density (Panel A) and the GDP per capita (Panel B) in the pre-expansion period, respectively (y-axis). The gray solid line represents a trend line resulting from a linear fit, with the corresponding slope and R-squared noted at the top.

Figure D-5: Experience-specific effect of the HE expansion rate on daily wages of full-time workers by skill groups: OLS vs. IV



Notes: The figure plots the β_e coefficients of the effect of the HE expansion rate on the log daily wages of full-time workers, varying by years of experience. The OLS estimates are obtained from equation (1), the IV estimates by instrumenting the HE expansion rate with a Bartik-type shift-share instrument. All models include region, cohort, calendar year, and experience year fixed effects and the unemployment rate as controls. The sample size in brackets in the panel header (in the order given in the legend) refers to the average total number of labor market entrants per year collapsed into region-year cells. 95 percent confidence intervals shown. Robust standard errors clustered at the cohort×region-level.

Table D-1: Relevance check: Effect of the initial HE expansion rate on the skill level of labor market entrants

	Share of high-skilled labor market entrants		
	(1)	(2)	(3)
HE expansion rate	2.221***	0.456***	0.465***
	(0.284)	(0.140)	(0.138)
Region FE	x	x	x
Year FE		x	x
Unemployment Rate			x
Observations	2,820	2,820	2,820
R-squared	0.529	0.634	0.635
Adj. R-squared	0.505	0.612	0.613

Notes: The table shows OLS estimates of the effect of the HE expansion rate at entry on the skill level of labor market entrants, measured as the share of high-skilled labor market entrants. The coefficients represent the percentage point change in the outcome due to a one-unit increase in the HE expansion rate, i.e., one college graduate per 1,000 inhabitants. Robust standard errors are clustered at the labor market region level and shown in parentheses. Calculations by the authors. Significance level: *** p<0.01, ** p<0.05, * p<0.1.

Table D-2: Balancing table: Effect of the initial HE expansion rate on the composition of labor market entrants I

	Gender	Age	Month of Entry
	(1)	(2)	(3)
HE expansion rate	0.0014	0.0343***	-0.0075
	(0.0013)	(0.0102)	(0.0089)
Region FE	x	x	x
Year FE	x	x	x
Unemployment Rate	x	x	x
Observations	346,683	346,683	346,683
R-squared	0.002	0.045	0.006
Adj. R-squared	0.002	0.045	0.006

Notes: The table shows OLS estimates of the effect of the HE expansion rate at entry on the composition of labor market entrants. The dependent variable is a gender dummy (1=female, 0=male) in column (1), the age of the labor market entrants in column (2), and the month of the labor market entry in column (3). All models include region and cohort fixed effects and the unemployment rate as controls. Unrestricted sample. Robust standard errors are clustered at the cohort×region-level and shown in parentheses. Calculations by the authors. Significance level: *** p<0.01, ** p<0.05, * p<0.1.

Table D-3: Balancing table: Effect of the initial HE expansion rate on the composition of labor market entrants II

	Age of labor market entrants		
	(1) LQ	(2) MQ	(3) HQ
HE expansion rate	0.0345	0.0333***	0.0072
	(0.0218)	(0.0109)	(0.0162)
Region FE	x	x	x
Year FE	x	x	x
Unemployment Rate	x	x	x
Observations	61,981	213,207	41,972
R-squared	0.018	0.061	0.023
Adj. R-squared	0.016	0.060	0.019

Notes: The table shows OLS estimates of the effect of the HE expansion rate at entry on the age of the labor market entrants (in years). In column (1) we use only low-skilled labor market entrants (LQ), in column (2) medium-skilled entrants (MQ), and in column (3) high-skilled entrants (HQ). All models include region and cohort fixed effects and the unemployment rate as controls. Unrestricted sample. Robust standard errors are clustered at the cohort×region-level and shown in parentheses. Calculations by the authors. Significance level: *** p<0.01, ** p<0.05, * p<0.1.

Table D-4: Balancing table: Explaining the HE expansion rate

	HE expansion rate	
	(1) All regions	(2) Pre-exp uni regions
Share school leavers w/ uni. entr. qual.	-0.006	-0.003
	(0.005)	(0.005)
Unemployment rate	-0.048	-0.055
	(0.043)	(0.059)
Share employment in industry	-0.030	-0.013
	(0.022)	(0.021)
Log population density	-0.084	-0.717
	(1.486)	(2.064)
Log GDP per capita	0.753	2.401
	(0.785)	(1.569)
Share population aged 18-25	0.183***	0.167**
	(0.060)	(0.069)
Share female population	0.262	0.050
	(0.301)	(0.274)
Share foreign population	0.019	0.125
	(0.086)	(0.108)
Observations	2820	1740
Reg and Year FE	x	x
Adj. R-squared	0.387	0.553
F-test	7.670	16.873
p-value joint F-test	0.036	0.037

Notes: The table reports estimates from regressing the HE expansion rate on regional characteristics. All coefficients on shares (and the unemployment rate) represent the effect of a one percentage point change on the HE expansion rate by one unit (i.e., one graduate per 1,000 inhabitants). All other coefficients represent the effect of a one percent change in the considered variable on the HE expansion rate by one unit. Pre-expansion university regions are defined as those that had at least 50 first-time graduates in 2000. The last row reports the p-value from an F-test of joint significance for all regional characteristics. Robust standard errors are clustered at the level of labor market regions and shown in parentheses. Calculations by the authors. Significance level: *** p<0.01, ** p<0.05, * p<0.1.

Table D-5: Balancing table: Explaining the change in the HE expansion rate, 2002-2012

	Δ HE expansion rate, 02-12	
	(1)	(2)
	All regions	Pre-exp uni regions
Share school leavers w/ uni. entr. qual., 2002	0.039	0.082*
	(0.032)	(0.044)
Unemployment rate, 2002	-0.140***	-0.200***
	(0.041)	(0.063)
Share employment in industry, 2002	-0.054***	-0.012
	(0.019)	(0.028)
Log population density, 2002	0.818***	0.798
	(0.311)	(0.510)
Log GDP per capita, 2002	0.451	-0.722
	(0.899)	(1.270)
Share population aged 18-25, 2002	1.212***	1.446***
	(0.200)	(0.277)
Share female population, 2002	0.214	-0.259
	(0.311)	(0.461)
Share foreign population, 2002	-0.086	-0.068
	(0.066)	(0.098)
Observations	141	87
Reg and Year FE	x	x
Adj. R-squared	0.339	0.324
F-test	9.987	6.160
p-value joint F-test	0.000	0.000

Notes: The table reports estimates from regressing the main HE expansion (2002-2012) on regional pre-expansion characteristics in 2002. All coefficients on shares (and the unemployment rate) represent the effect of a one percentage point change on the college graduation rate in graduates per 1,000 inhabitants. All other coefficients represent the effect of a one percent change in the considered variable on the college graduation rate in graduates per 1,000 inhabitants. Pre-expansion university regions are defined as those that had at least 50 first-time graduates in 2000. The last row reports the p-value from an F-test of joint significance for all regional characteristics. Robust standard errors are clustered at the level of labor market regions and shown in parentheses. Calculations by the authors. Significance level: *** p<0.01, ** p<0.05, * p<0.1.

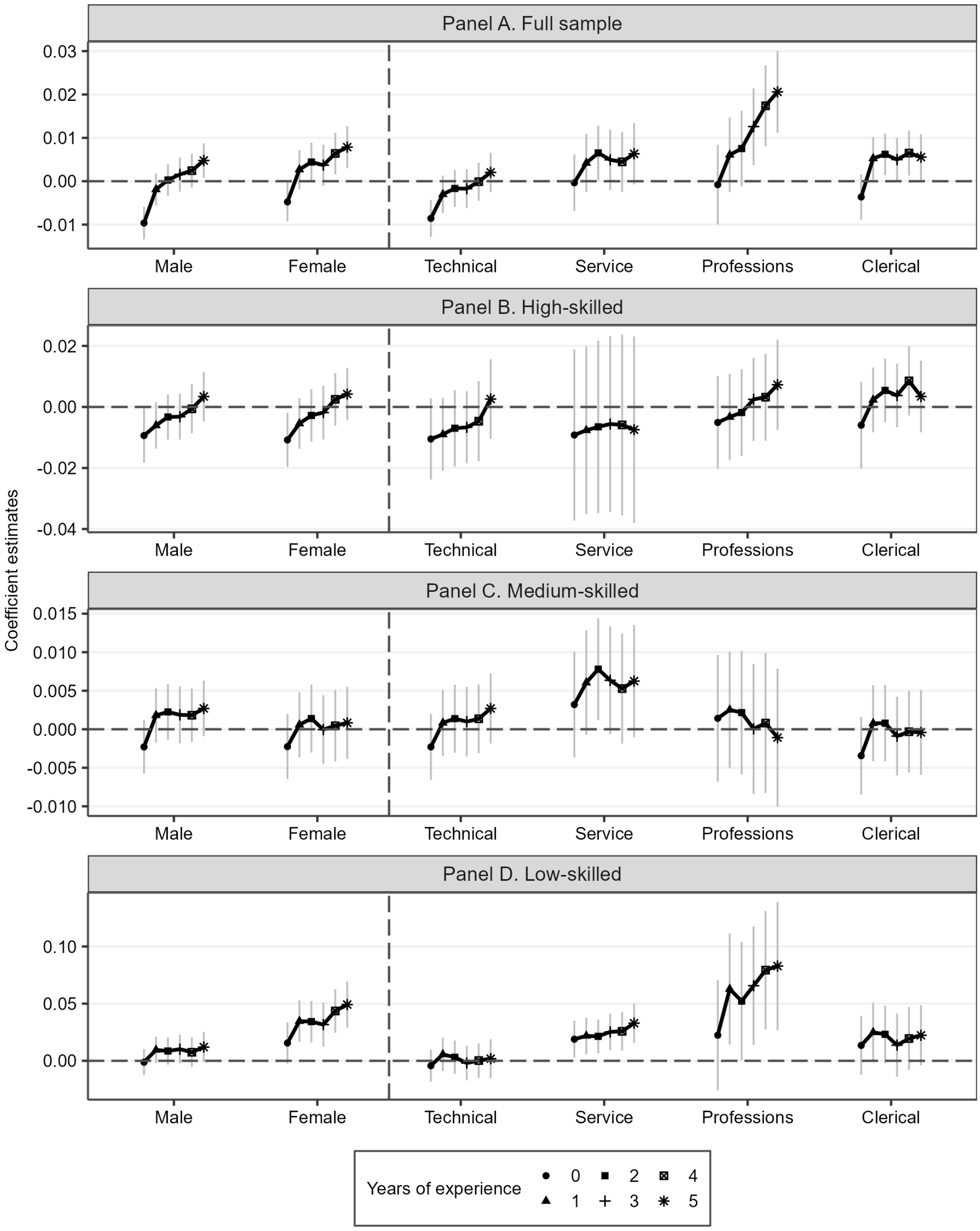
Table D-6: First stage results

	HE expansion rate	
	(1)	(2)
Bartik-type instrument ($x^*_{r,c}$)	0.8635***	0.6984***
	(0.0769)	(0.1153)
Region FE	x	x
Year FE		x
Observations	2,961	2,961
F-Statistic	126.25	25.13

Notes: The table shows first-stage results for regressing the HE expansion rate on the Bartik-type instrument that is defined as national graduation trends scaled with the regional share of university enrollment in 1992 (see Section D for details). Column (1) uses only region fixed effects and represents our main first-stage for the results shown in Figure 4 in the main paper, column (2) adds year fixed effects. Standard errors are clustered at the region-level and shown in parentheses. Calculations by the authors. Significance level: *** p<0.01, ** p<0.05, * p<0.1.

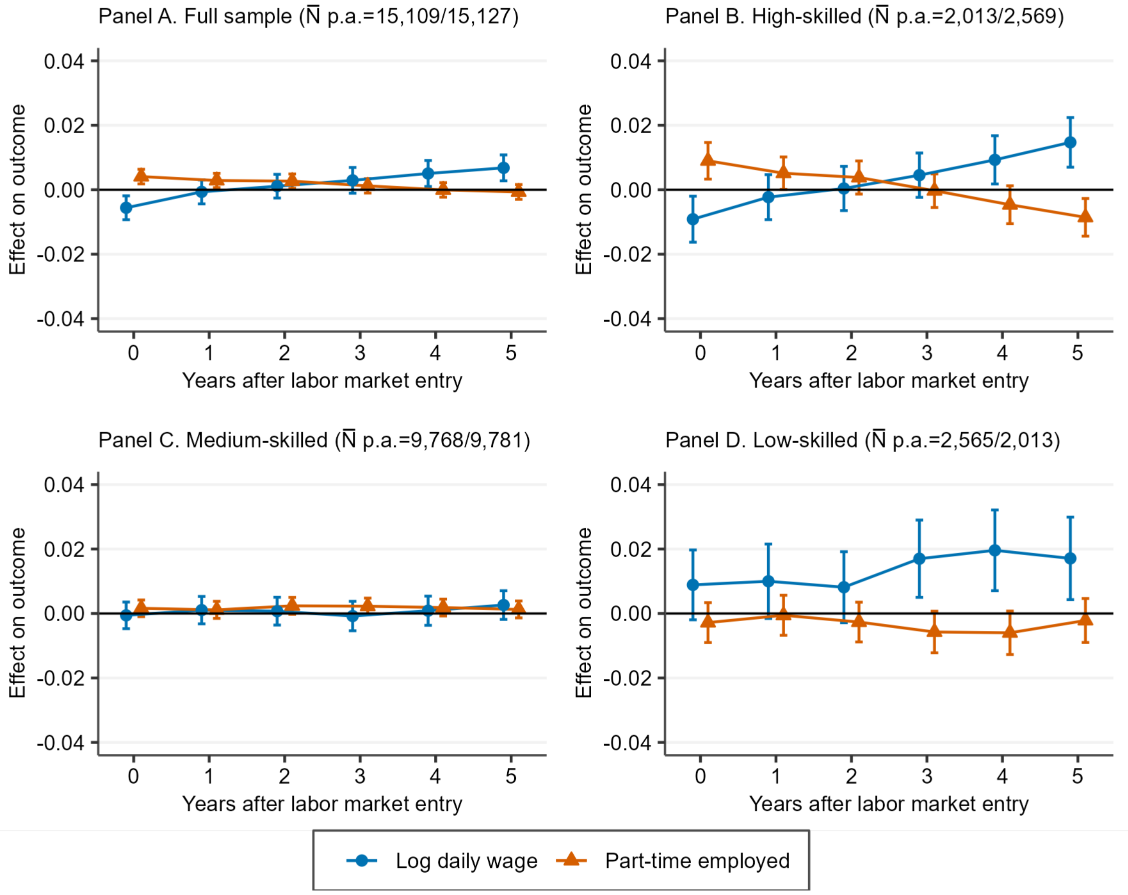
E Additional Regression Results

Figure E-1: Gender and occupational heterogeneity



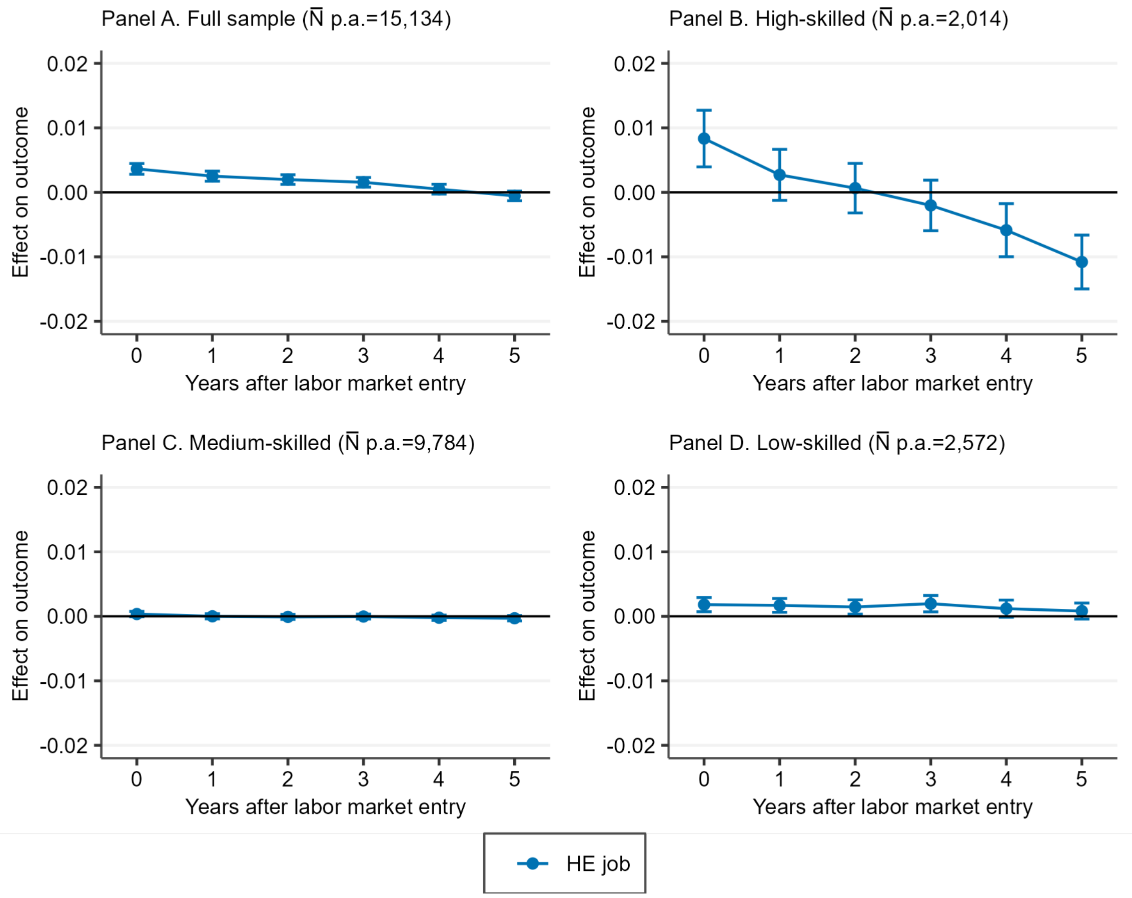
Notes: The figure plots the β_e coefficients from estimating equation (1) for gender and occupational subgroups. The coefficients represent the effect of the HE expansion rate on log daily wages of full-time workers in the respective skill group (panels) varying by experience year (points). Occupational subgroups are defined based on the classification by Blossfeld (1987), as described in Dauth and Eppelsheimer (2020). To increase sample size, we group the 12 Blossfeld occupations into the following categories: simple manual jobs (2), qualified manual jobs (3), technicians (4), and engineers (5): "technical"; simple services (6) and qualified services (7): "service"; semi-professions (8) and professions (9): "professions" (mostly in health, social work, education); simple clerical jobs (10) and qualified clerical jobs (11): "clerical". Agricultural jobs (1) and manager (12) are dropped due to small sample sizes. All models include region, cohort, calendar year, and experience year fixed effects and the unemployment rate as controls. 95 percent confidence intervals shown. Robust standard errors clustered at the cohort×region-level. Own calculation based on the weakly anonymous Sample of Integrated Labor Market Biographies (SIAB) 1975 - 2017.

Figure E-2: Experience-specific effect of the HE expansion rate on wages of all workers and on part-time employment by skill groups



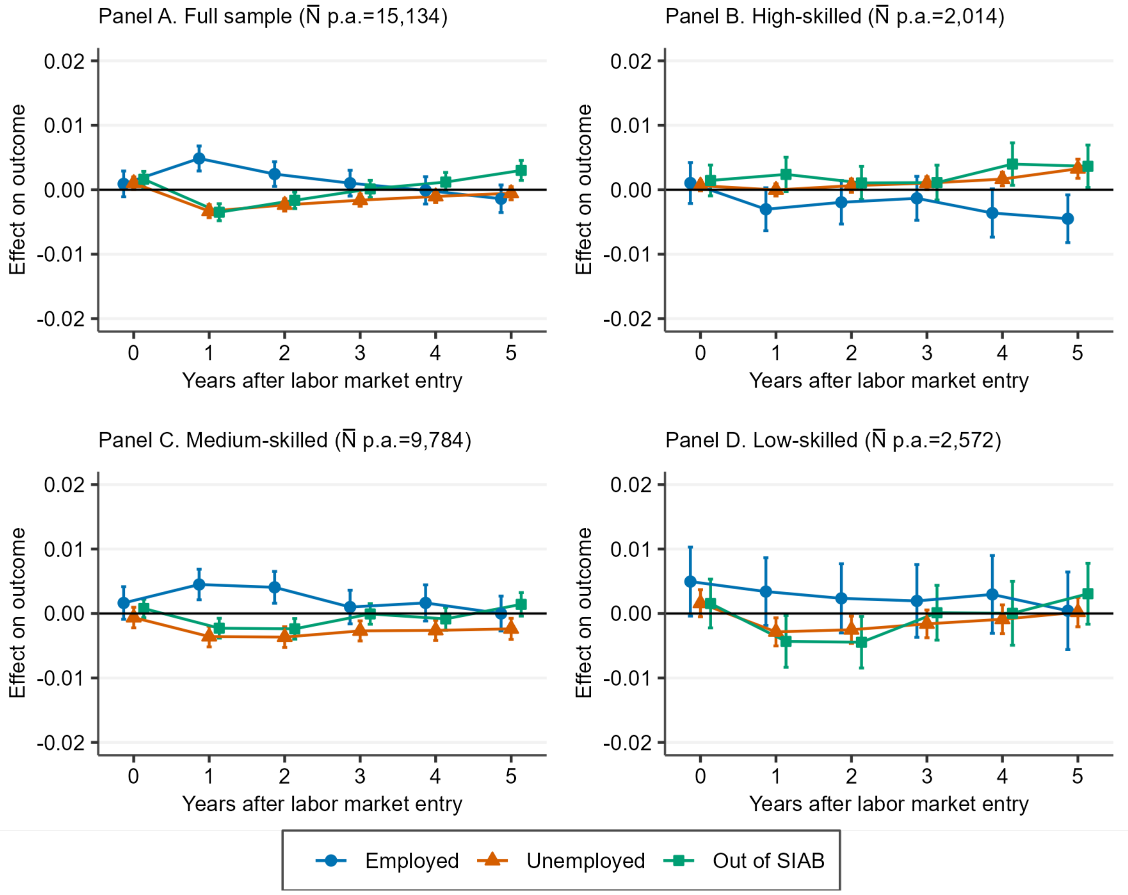
Notes: The figure plots the β_e coefficients from estimating equation (1), using log daily wages of all workers and part-time employment as the outcome variables. All models include region, cohort, calendar year, and experience year fixed effects and the unemployment rate as controls. The sample size in brackets in the panel header (in the order given in the legend) refers to the average total number of labor market entrants per year collapsed into region-year cells. 95 percent confidence intervals shown. Robust standard errors clustered at the cohort×region-level. Own calculation based on the weakly anonymous Sample of Integrated Labor Market Biographies (SIAB) 1975 - 2017.

Figure E-3: Experience-specific effect of the HE expansion rate on employment in HE jobs by skill groups



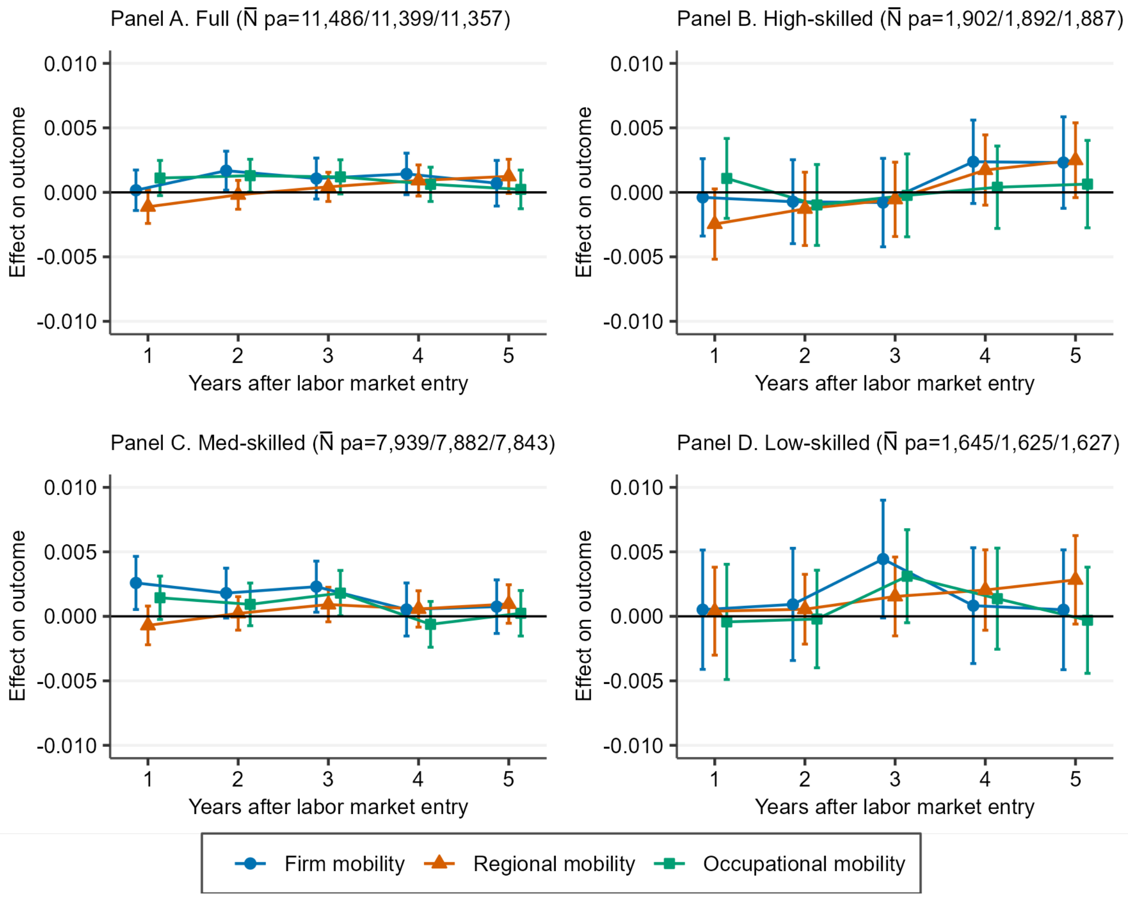
Notes: The figure plots the β_e coefficients from estimating equation (1), using the probability of being employed in the HE sector as the outcome variable. All models include region, cohort, calendar year, and experience year fixed effects and the unemployment rate as controls. The sample size in brackets in the panel header refers to the average total number of labor market entrants per year collapsed into region-year cells. 95 percent confidence intervals shown. Robust standard errors clustered at the cohort×region-level. Own calculation based on the weakly anonymous Sample of Integrated Labor Market Biographies (SIAB) 1975 - 2017.

Figure E-4: Experience-specific effect of the HE expansion rate on employment status by skill groups



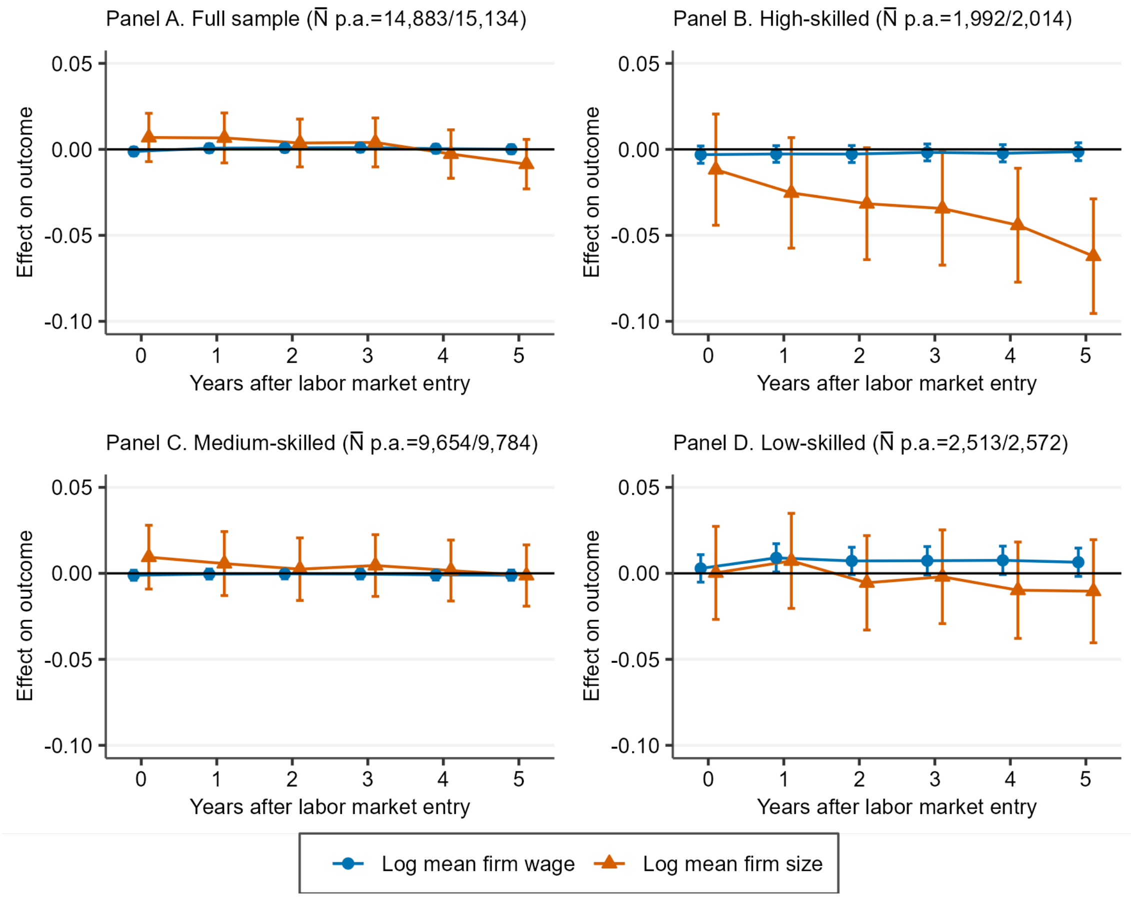
Notes: The figure plots the β_e coefficients from estimating equation (1), using as outcome variables the probability of being employed subject to social security contributions, of being unemployed, and of being out of the SIAB. All models include region, cohort, calendar year, and experience year fixed effects and the unemployment rate as controls. The sample size in brackets in the panel header refers to the average total number of labor market entrants per year collapsed into region-year cells. 95 percent confidence intervals shown. Robust standard errors clustered at the cohort×region-level. Own calculation based on the weakly anonymous Sample of Integrated Labor Market Biographies (SIAB) 1975 - 2017.

Figure E-5: Experience-specific effect of the HE expansion rate on job mobility by skill groups



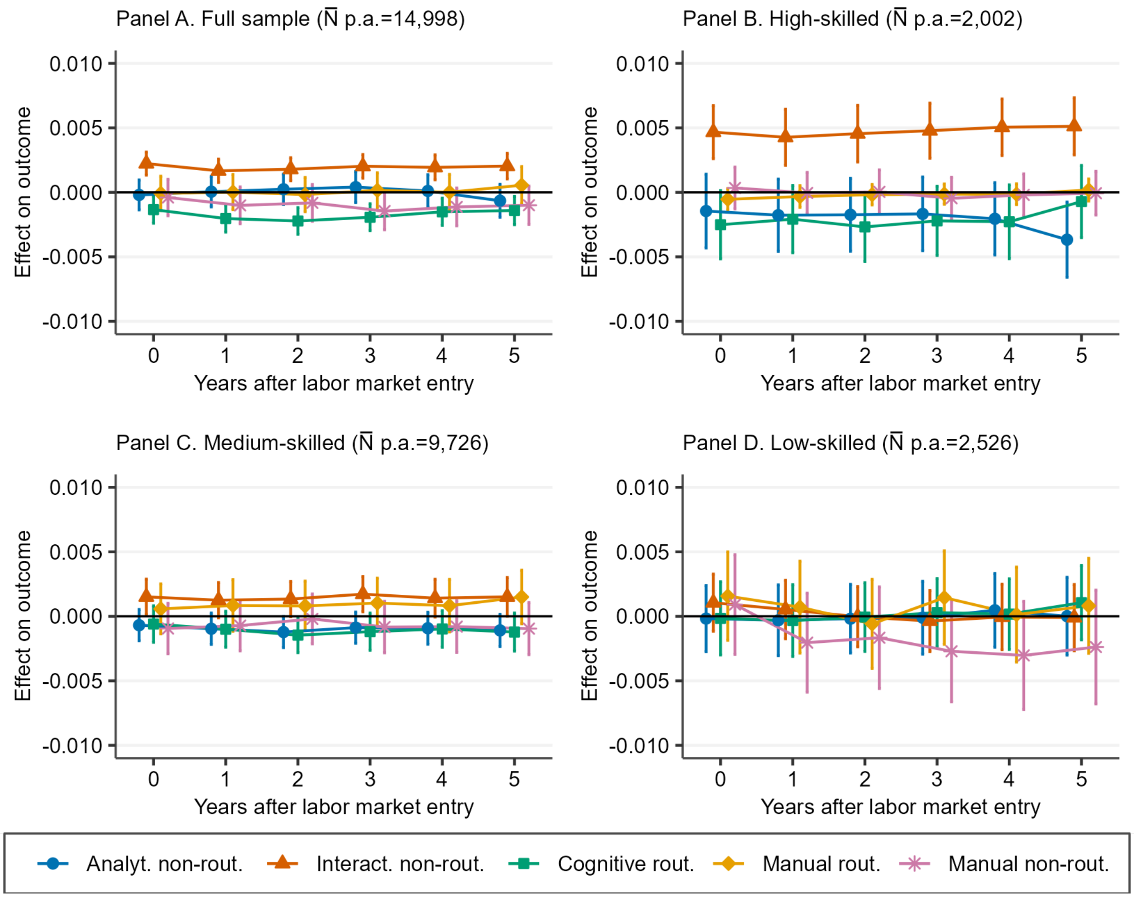
Notes: The figure plots the β_e coefficients from estimating equation (1), using firm mobility, regional mobility, and occupational mobility as outcome variables. All models include region, cohort, calendar year, and experience year fixed effects and the unemployment rate as controls. The sample size in brackets in the panel header (in the order given in the legend) refers to the average total number of labor market entrants per year collapsed into region-year cells. 95 percent confidence intervals shown. Robust standard errors clustered at the cohort×region-level.

Figure E-6: Experience-specific effect of the HE expansion rate on employer quality by skill groups



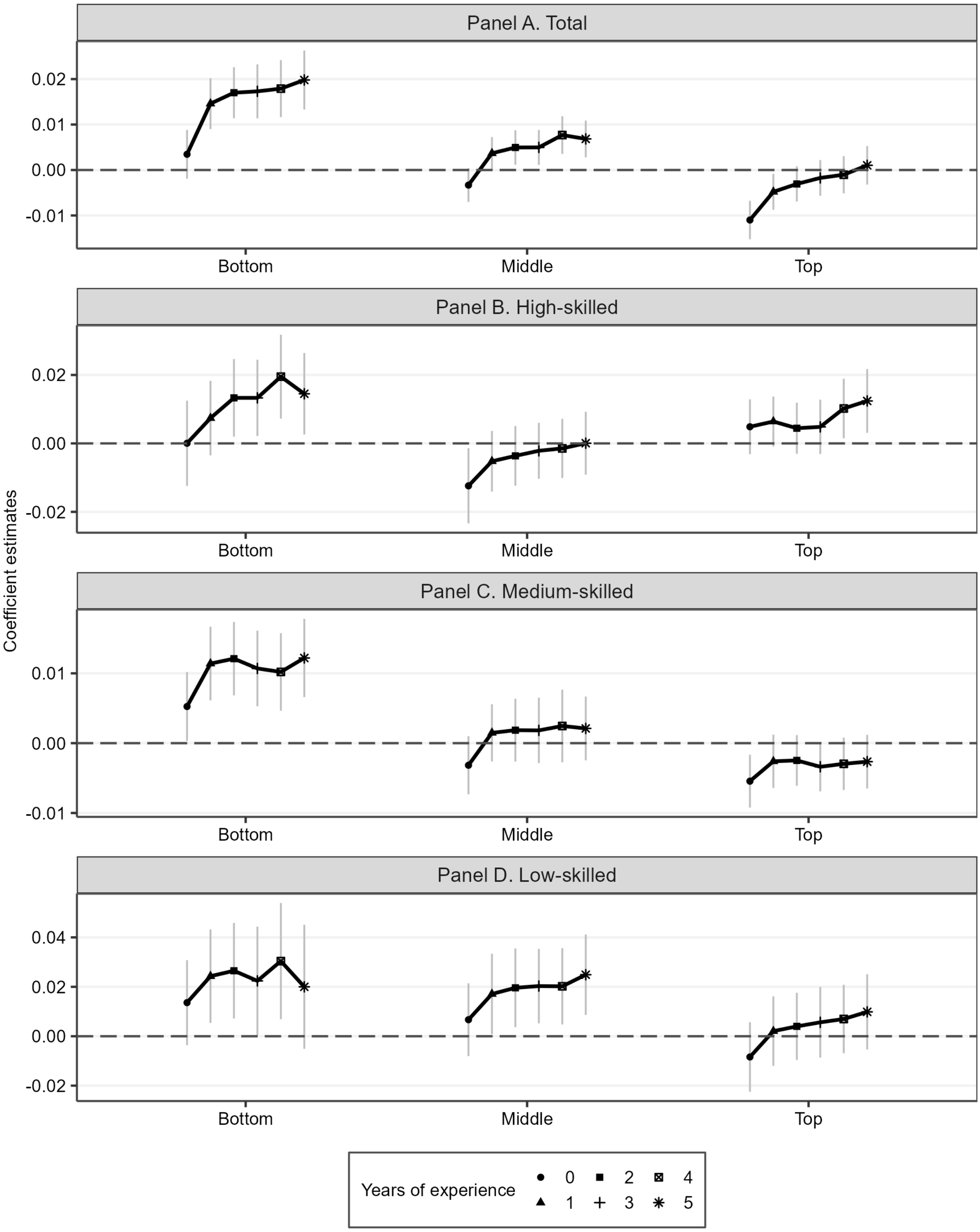
Notes: The figure plots the β_e coefficients from estimating equation (1), using the log average size and the log average wage level of the employing firms of labor market entrants as outcome variables. All models include region, cohort, calendar year, and experience year fixed effects and the unemployment rate as controls. The sample size in brackets in the panel header (in the order given in the legend) refers to the average total number of labor market entrants per year collapsed into region-year cells. 95 percent confidence intervals shown. Robust standard errors clustered at the cohort×region-level.

Figure E-7: Experience-specific effect of the HE expansion rate on task intensity by skill groups



Notes: The figure plots the β_e coefficients from estimating equation (1), using as outcome variables the intensity of analytical non-routine, interactive non-routine, cognitive routine, manual routine, and manual non-routine tasks (based on the classification by Dengler et al. 2014). All models include region, cohort, calendar year, and experience year fixed effects and the unemployment rate as controls. The sample size in brackets in the panel header refers to the average total number of labor market entrants per year collapsed into region-year cells. 95 percent confidence intervals shown. Robust standard errors clustered at the cohort×region-level.

Figure E-8: Ability heterogeneity



Notes: The figure plots the β_e coefficients from estimating equation (1) for ability subgroups. The coefficients represent the effect of the HE expansion rate on log daily wages of full-time workers in the respective skill group (panels) varying by years of labor market experience (points). Different subsamples are presented on the x-axis. See text for details. All models include region, cohort, calendar year, and experience year fixed effects and the unemployment rate as controls. 95 percent confidence intervals shown. Robust standard errors clustered at the cohort×region-level. Own calculation based on the weakly anonymous Sample of Integrated Labor Market Biographies (SIAB) 1975 - 2017.

Table E-1: Wage and employment effects of the HE expansion rate

Dependent variable	Full Sample		
Experience year	(1)	(2)	(3)
Panel A. Log full-time daily wage:			
0	-0.0110***	-0.0083***	-0.0079***
	(0.0169)	(0.0017)	(0.0016)
1	-0.0022	-0.0012	0.0002
	(0.0017)	(0.0017)	(0.0016)
2	0.0013	0.0011	0.0020
	(0.0017)	(0.0017)	(0.0016)
3	0.0032*	0.0014	0.0022
	(0.0018)	(0.0018)	(0.0017)
4	0.0063***	0.0029*	0.0037**
	(0.0018)	(0.0018)	(0.0017)
5	0.0095***	0.0048***	0.0054***
	(0.0018)	(0.0018)	(0.0018)
Observations	16,074	16,074	16,074
Average cell sum	12,229	12,229	12,229
Panel B. Log annual days employed:			
1	0.0044	0.0099**	0.0121***
	(0.0043)	(0.0043)	(0.0041)
2	0.0032	0.0054	0.0069*
	(0.0042)	(0.0042)	(0.0040)
3	0.0075*	0.0053	0.0066
	(0.0045)	(0.0045)	(0.0044)
4	0.0157***	0.0093**	0.0104**
	(0.0046)	(0.0046)	(0.0045)
5	0.0190***	0.0085*	0.0094**
	(0.0050)	(0.0050)	(0.0048)
Observations	16,074	16,074	16,074
Average cell sum	13,254	13,254	13,254
Region FE	x	x	x
Cohort FE	x	x	x
Experience Year FE	x	x	x
Calendar Year FE		x	x
Unemployment Rate			x

Notes: The table shows main OLS estimates of the effect of the initial HE expansion rate on different labor market outcomes in a given experience year. The dependent variables are in logs, hence the coefficients can be interpreted as semi-elasticities and approximately represent the $x \times 100\%$ change in the outcome due to the increase of first-time graduates by one per 1,000 inhabitants. Column (3) refers to the model specified in equation (1). Robust standard errors are clustered at the cohort×region-level and shown in parentheses. Calculations by the authors. Significance level: *** p<0.01, ** p<0.05, * p<0.1.

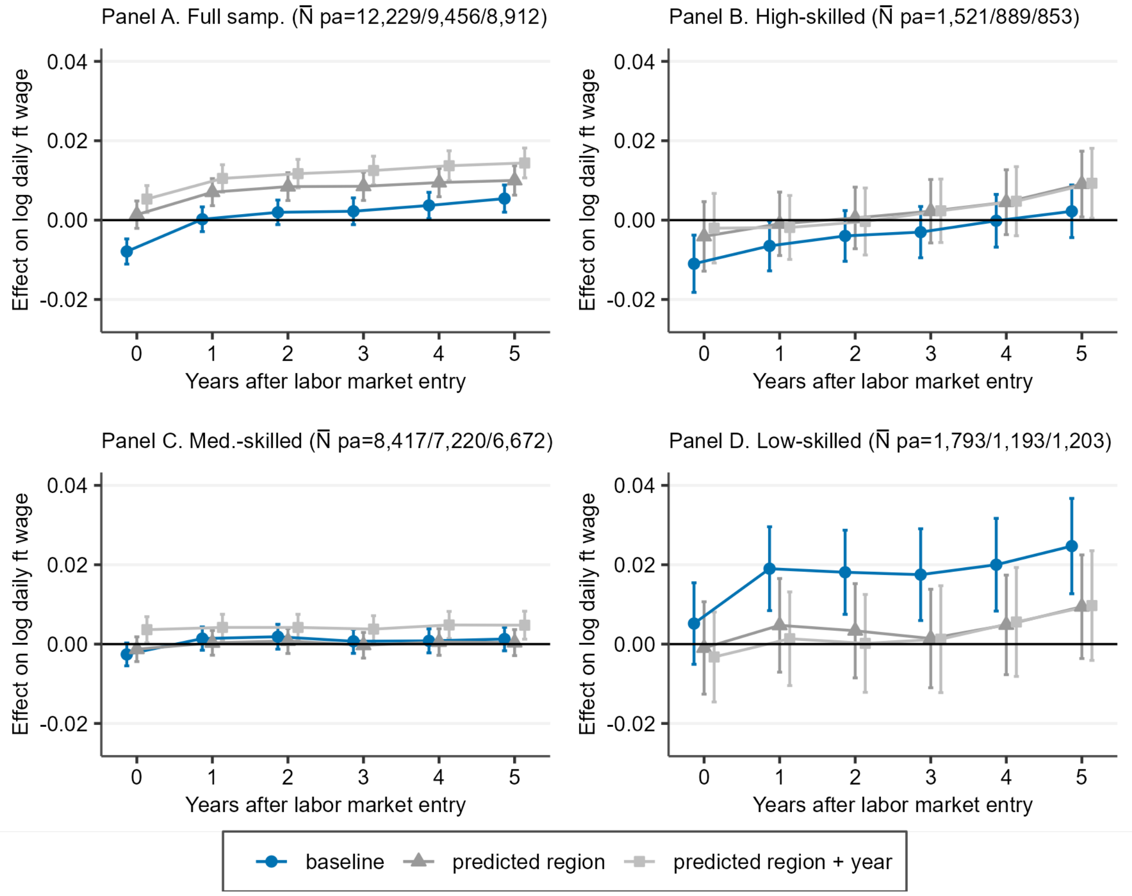
Table E-2: Wage and employment effects of the HE expansion rate by skill group

Dependent variable	Low-skilled	Medium-skilled	High-skilled
Experience year	(1)	(2)	(3)
Panel A. Log full-time daily wage:			
0	0.0052	-0.0026*	-0.0110***
	(0.0052)	(0.0015)	(0.0037)
1	0.0190***	0.0014	-0.0065**
	(0.0054)	(0.0015)	(0.0032)
2	0.0181***	0.0019	-0.0040
	(0.0054)	(0.0016)	(0.0033)
3	0.0175***	0.0007	-0.0030
	(0.0059)	(0.0016)	(0.0033)
4	0.0200***	0.0008	-0.0002
	(0.0061)	(0.0015)	(0.0034)
5	0.0247***	0.0012	0.0022
	(0.0061)	(0.0015)	(0.0034)
Observations	7,805	8,178	7,786
Average cell sum	1,793	8,417	1,521
Panel B. Log annual days employed:			
1	0.0318**	0.0153***	-0.0013
	(0.0153)	(0.0046)	(0.0049)
2	0.0054	0.0137***	-0.0067
	(0.0160)	(0.0047)	(0.0051)
3	0.0177	0.0088*	-0.0071
	(0.0168)	(0.0048)	(0.0054)
4	0.0292	0.0085*	0.0058
	(0.0179)	(0.0051)	(0.0063)
5	0.0279	0.0101*	0.0050
	(0.0181)	(0.0054)	(0.0066)
Observations	6,685	6,768	6,541
Average cell sum	1,910	8,673	1,945
Region FE	x	x	x
Cohort FE	x	x	x
Experience Year FE	x	x	x
Calendar Year FE	x	x	x
Unemployment Rate	x	x	x

Notes: The table shows main OLS estimates of the effect of the initial HE expansion rate on different labor market outcomes in a given experience year. The dependent variables are in logs, hence the coefficients can be interpreted as semi-elasticities and approximately represent the $x \times 100\%$ change in the outcome due to the increase of first-time graduates by one per 1,000 inhabitants. The estimates refer to the model specified in equation (1). Robust standard errors are clustered at the cohort×region-level and shown in parentheses. Calculations by the authors. Significance level: *** p<0.01, ** p<0.05, * p<0.1.

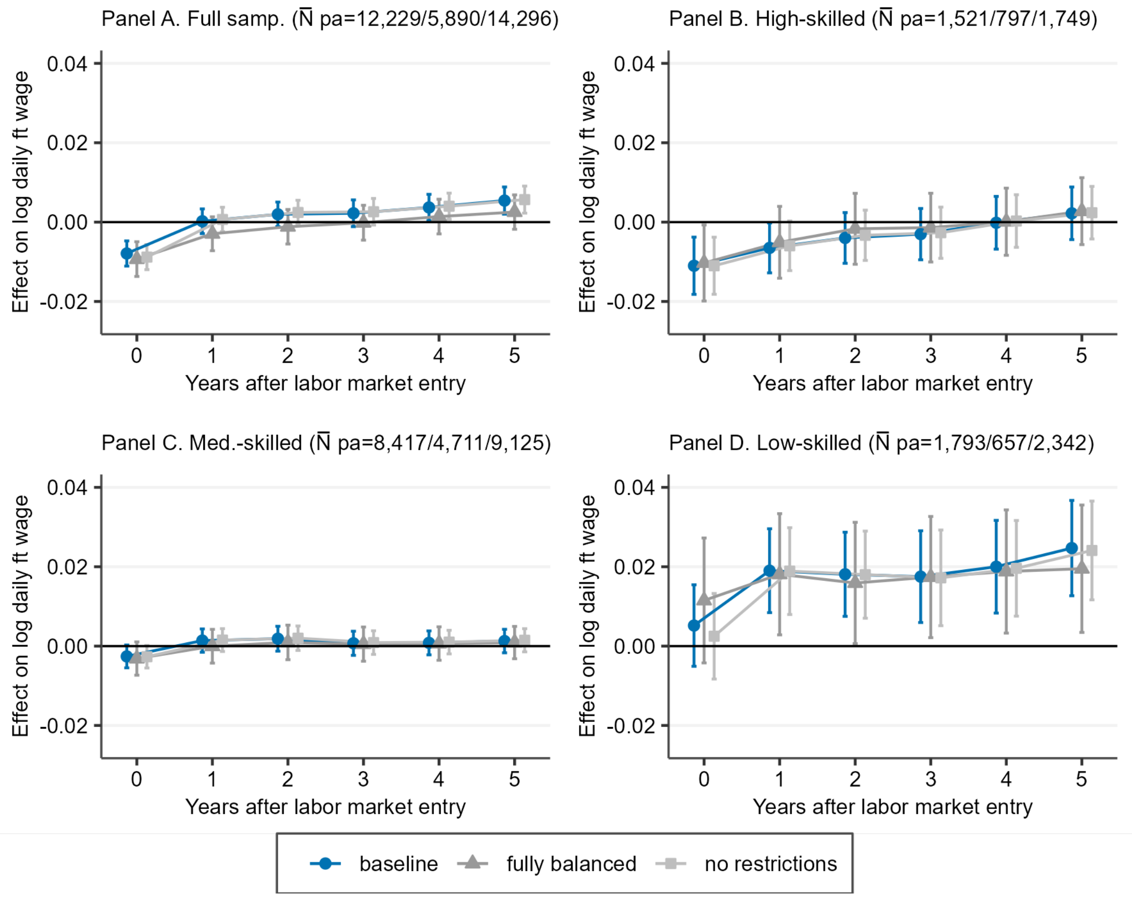
F Robustness Checks

Figure F-1: Experience-specific effect of the HE expansion rate on full-time daily wages by skill group: predicted entry cohorts



Notes: The figure plots the β_e coefficients from estimating equation (1). "Baseline" refers to the main results of the paper, "predicted region" and "predicted region + year" refer to a robustness check where HE expansion rates are matched to the individual labor market data by using the predicted region of graduation and predicted region of graduation and year, respectively (see text for details). The sample size in brackets in the panel header (in the order given in the legend) refers to the average total number of labor market entrants per year collapsed into region-year cells. All models include region, cohort, calendar year, and experience year fixed effects and the unemployment rate as controls. 95 percent confidence intervals shown. Robust standard errors clustered at the cohort×region-level. Own calculation based on the weakly anonymous Sample of Integrated Labor Market Biographies (SIAB) 1975 - 2017.

Figure F-2: Experience-specific effect of the HE expansion rate on full-time daily wages by skill group: sample selections



Notes: The figure plots the β_e coefficients from estimating equation (1). "Baseline" refers to the main results of the paper, "fully balanced" and "no restrictions" refer to robustness checks that use a fully balanced panel data set and a completely unrestricted sample, respectively (see text for details). The sample size in brackets in the panel header (in the order given in the legend) refers to the average total number of labor market entrants per year collapsed into region-year cells. All models include region, cohort, calendar year, and experience year fixed effects and the unemployment rate as controls. 95 percent confidence intervals shown. Robust standard errors clustered at the region-level. Own calculation based on the weakly anonymous Sample of Integrated Labor Market Biographies (SIAB) 1975 - 2017.

Table F-1: Interaction effects between the HE expansion rate and the share of BA graduates

	0 years	2 years	5 years
	(1)	(2)	(3)
Log daily full-time wage:			
HE expansion rate	-0.0068**	0.0046*	0.0060**
	(0.0029)	(0.0027)	(0.0028)
Share BA grad	-0.0003*	-0.0001	-0.0000
	(0.0001)	(0.0001)	(0.0002)
HE expansion rate x share BA grad	0.0000	-0.0000	-0.0000
	(0.0000)	(0.0000)	(0.0000)
Observations	16,074	16,074	16,074
Region FE	x	x	x
Cohort FE	x	x	x
Experience Year FE	x	x	x
Calendar Year FE	x	x	x
Unemployment Rate	x	x	x

Notes: The table shows main OLS estimates of the interaction effect of the HE expansion rate at entry and the share of BA graduates on different labor market outcomes in a given experience year. The dependent variables are in logs, hence the coefficients can be interpreted as semi-elasticities and approximately represent the $x \times 100\%$ change in the outcome due to the increase the respective variable by one unit. Robust standard errors are clustered at the cohort×region-level and shown in parentheses. Calculations by the authors. Significance level: *** p<0.01, ** p<0.05, * p<0.1.

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