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The Role of Vocational Training in Addressing Skilled Labor Shortages

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Abstract

This study examines how regional and occupation-specific skilled labor shortages influence companies' involvement in apprenticeship training. It explores the relationship between skilled labor shortages and demand for apprentices, qualification requirements, new apprenticeship contracts, and premature contract terminations in Germany. Skilled labor shortages are measured using the ratio of unemployed skilled jobseekers to job vacancies and a skilled labor shortage indicator from the Federal Employment Agency. Involvement in apprenticeship training is measured using annual apprenticeship contract data. To estimate the relationship between skilled labor shortages and apprenticeship activities, the study uses a two-way fixed effects model and a robust difference-in-differences approach. The findings show that skilled labor shortages bring about higher demand for apprentices and more hires, with companies recruiting a larger share of apprentices with lower qualifications. However, the impact on premature contract terminations remains unclear. Additionally, the study reveals significant variation across occupations in how companies adjust apprenticeship practices.

JEL-Codes: M53, J63

Keywords: Skilled Labor Shortages, Vocational Education and Training (VET), Apprenticeships

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1 Introduction

Skilled labor shortages have become a prominent topic in the news and political debates in Germany and many advanced economies. These shortages are typically defined as a situation in which the demand for workers in a particular occupation exceeds the supply of individuals who are qualified, available and willing to work under prevailing market conditions (Shah and Burke [2005]). While apprenticeship training could be a reasonable strategy for companies to mitigate skilled labor shortages, it remains largely understudied to what extent companies actually increase their training efforts in response to such shortages.

Not only is there limited empirical research on companies' responses to skilled labor shortages, there is also little research on skilled labor shortages in general. A systematic review by McGuinness et al. [2018] identified only seven studies on labor shortages - defined as "unfilled or hard-to-fill vacancies that have arisen as a consequence of a lack of qualified candidates for posts" - published between 2006 and 2017, compared to, e.g., nearly 100 studies on overeducation. Moreover, several studies have challenged the notion of persistent skilled labor shortages, arguing that employers adapt their skill requirements to the level of unemployment and that unfilled vacancies often result from mismatched skill demands or unattractive working conditions (Green and Ashton [1992], Handel [2005], Osterman and Weaver [2014], Modestino et al. [2016] and Cappelli [2014]). This view aligns with neoclassical labor market theory, which states that short-term imbalances between labor demand and supply are corrected through wage increases.

More recently, however, skilled labor shortages have gained slightly more recognition in the academic literature, leading to a growing body of research on their drivers and consequences. Studies examine persistent skilled labor shortages in specific sectors, such as construction (Kim et al. [2020], Cerić and Ivić [2020], Elbashbishy and El-adaway [2024]), ITC (Finnie et al. [2018], Asliturk et al. [2016], Hyrynsalmi et al. [2021]) and healthcare (Liu et al. [2017], Michaeli et al. [2024], Kroczek and Koch [2024]). Other research investigates skill shortages and mismatches in the context of technological advancements and productivity (Horbach and Rammer [2022], Morris et al. [2020]) as well as structural changes like demographic shifts (Ette et al. [2016], Albattah et al. [2015]). In addition, institutions are increasingly publishing rankings of the occupations most affected by skilled labor shortages (Cedefop [2019], BA [2024b], Jobs and Skills Australia [2024]). Meanwhile, some scholars, particularly those analyzing the US labor market, continue to argue that skill mismatches often stem from firms raising hiring requirements during periods of high unemployment rather than from genuine labor shortages (Zickuhr [2022], Handel [2024]).

Most research on skilled labor shortages relies on employer surveys or broad indicators that measure whether labor demand and supply align in terms of general education levels like skilled vs. unskilled (un)employment ratios or vacancy durations by skill level (Blair and Deming [2020], Burke et al. [2020], Abbritti and Consolo [2024], Arpaia et al. [2014], Rutkowski [2007]). These measures fail to capture differences across specializations, masking

shortages in some occupations with surpluses in others.[1] Employer surveys, on the other hand, may be influenced by question framing, as shown by contrasting U.S. manufacturing surveys (The U.S. Manufacturing Institute and accenture [2014], Osterman and Weaver [2014]). Additionally, a company's perception of shortages may be skewed if it struggles to fill a highly specialized position while other roles could be filled immediately. Few studies move beyond surveys or skill-level mismatch indicators to analyze occupation-specific shortages, typically using U.S. job ad data like Help Wanted OnLine (Şahin et al. [2014]) or machine learning on other platforms (Dawson et al. [2020]). In this context, the data from the BA [2024b], including occupation- and region-specific vacancy counts, unemployment rates and other indicators which is used in the present study offers rare, detailed insights into skilled labor shortages in Germany by occupation and region.

In light of the still limited empirical research on how companies respond to skilled labor shortages, a particularly intriguing question is whether companies address this challenge by increasing their investment in education, especially vocational education. In this context, Germany presents a particularly interesting case, as its vocational training system allows firms to decide independently whether to offer apprenticeships and which candidates to hire. From a theoretical standpoint, there are arguments that companies may use apprenticeships to develop their own workforce when skilled workers are scarce. This is because, throughout their training, apprentices gradually take on more complex tasks and acquire knowledge specifically tailored to the company's operations, ultimately making them valuable assets. However, training is costly and requires skilled labor to train the apprentices, temporarily reducing skilled workforce availability. Additionally, in fast-changing and unpredictable industries, the skills needed today may become irrelevant to the company by the time apprentices complete their training. Finally, general, non-company-specific training (such as, to some extent, apprenticeship training in Germany, which follows a state-mandated curriculum) carries the risk that apprentices may be poached by other companies after their training (Becker [1964], Acemoglu and Pischke [1999], Muehlemann and Wolter [2011], Mueller [2014], Mohrenweiser et al. [2019]).

So far, empirical research on whether firms expand apprenticeship programs in response to labor shortages has yielded mixed results. On the one hand, a company survey conducted by the IHK Munich [2024] indicates that 41 % of companies intend to address these shortages by increasing their apprenticeship postings. Several studies suggest that companies are more likely to invest in apprenticeship training when recruiting costs rise, which is typically the case when skilled labor becomes scarce (Aepli et al. [2024], Blatter et al. [2016], Oswald-Egg and Siegenthaler [2021]). Additionally, Stevens [1994] finds a positive relationship between a skill shortage index from a company survey and apprentice recruitment in the British industrial sector. On the other hand, a company survey-based study by Mason et al. [2012]

[1] For example, Germany has recently lacked healthcare workers while having a surplus in media and information services (BA [2024b]), yet the above indicators would treat supply and demand in both fields as equivalent due to similar education levels, potentially suggesting no overall shortage of skilled labor.

finds that New Zealand companies facing skilled labor shortages are more likely to invest in training but focus on upskilling current employees rather than training new apprentices. Meanwhile, evidence from a 2024 ifo survey shows that 15 % of HR managers in Germany plan to discontinue apprenticeship programs, with half citing staffing constraints caused by existing skilled labor shortages as one reason for their decision (ifo Institut [2025]). These conflicting findings underscore the need for a deeper understanding of how companies respond to skilled labor shortages and whether they turn toward apprenticeship training as a solution.
In addition to limited research on skilled labor shortages and apprenticeships, some studies explore the link between overall labor market tightness - often measured by (local) unemployment - and apprenticeships. Unlike skilled labor shortages, the concept of labor market tightness does not consider required or available skills. Instead, it focuses on the number of jobseekers and primarily reflects fluctuations in the business cycle. Most studies find that higher (regional) unemployment correlates with fewer apprenticeships or company-sponsored training programs (Muehlemann et al. [2009], Majumdar [2007], Bertoni and Brunello [2022], Askilden and Nilsen [2005], Bolli and Morlet [2023]). Some also use natural experiments to show that increased labor supply reduces apprenticeship training (Oswald-Egg and Siegenthaler [2021], Shirshikova [2024], Aepli and Kuhn [2021], Neuber-Pohl et al. [2023]).
In contrast, the concept of skilled labor shortages - as defined by Shah and Burke [2005] - focuses on mismatches between specific skills demanded and supplied. These shortages can persist during high unemployment if workers lack needed skills and are more often driven by structural than cyclical factors, making them closely linked to structural unemployment (Restrepo [2015]). Demand-side drivers include industry growth or decline, technological advances, and regulatory changes, while supply-side factors include demographic shifts, changes in working conditions and wages, immigration trends, and fluctuations in vocational training participation and completion rates (Brunello and Wruuck [2021]).
The present study examines the relationship between regional and occupation-specific skilled labor shortages and companies' apprenticeship activities. Specifically, it investigates how shortages influence companies' demand for apprentices, their qualification requirements for applicants, the number of successfully established apprenticeship contracts, and the share of prematurely terminated apprenticeships. Additionally, it examines whether companies adapt their training strategies differently across various occupations to address these shortages.
To quantify skilled labor shortages at the occupational and regional levels, this study employs two measures: (1) the ratio of unemployed skilled jobseekers to vacancies, as provided by the German Federal Employment Agency (BA), and (2) a skilled labor shortage indicator developed by the BA, which accounts for factors such as vacancy duration, the jobseeker-to-vacancy ratio, unemployment trends, and wage growth. Companies' apprenticeship involvement is quantified using annual register data on apprenticeship contracts and BA records. The empirical approach leverages regional and occupational variations, applying two-way fixed effects (TWFE) estimations and a robust difference-in-differences (DiD) strategy as

developed by de Chaisemartin et al. [2024].
The findings indicate that growing skilled labor shortages bring about increased demand for apprentices and a rise in apprenticeship hires. Additionally, companies facing skilled labor shortages tend to recruit a larger share of apprentices with lower educational qualifications. However, the impact on premature contract terminations remains ambiguous. Heterogeneity analyses show substantial differences across occupations, indicating that companies mainly adapt their apprenticeship strategies in response to severe shortages, whereas in less affected occupations, adjustments to skilled labor shortages are more inconsistent.
The paper is structured as follows. Section 2 discusses the German apprenticeship system and current labor market conditions. Section 3 details the methodological approach, while Section 4 describes the data sources. The results are presented in Section 5, and Section 6 concludes.

2 Apprenticeship System and Labor Market

In Germany, apprenticeships are organized in a publicly regulated dual system, typically involving 2 to 3.5 years of structured on-the-job training in companies, complemented with lessons at vocational schools which provide the necessary theoretical knowledge and broaden the general knowledge of apprentices. The decision whether and how many apprenticeship positions to offer and which occupations to train is up to the companies. They must, however, follow the training regulations for the corresponding occupation, which specify, among other things, the skill set and content taught.
In 2023, there were 327 officially recognized vocational training occupations in Germany (Bundesinstitut für Berufsbildung [2023]). To establish an apprenticeship relationship, companies advertise apprenticeship positions, potential apprentices apply, and then a bilateral apprenticeship contract is concluded between the selected candidate and the company specifying various details including hours and the apprentice's remuneration.
The apprenticeship system is a key cornerstone of the German post-secondary education system and serves as an important source of qualified employees for companies. Each year around 500,000 new apprentices start an apprenticeship in one of approximately 420,000 companies (which makes up around 19 % of all companies with employees covered by social insurance in Germany, Bundesinstitut für Berufsbildung [2023]). Approximately 72 % of the apprentices who successfully complete their training are hired by the company immediately afterward, underscoring the importance of vocational training for companies to develop a skilled workforce (Bundesinstitut für Berufsbildung [2022]). Companies play an active role in shaping the curriculum, providing hands-on training, and mentoring apprentices. This close collaboration between businesses and the vocational education system ensures that the skills taught align closely with industry requirements, making graduates highly employable. Because mid-level skilled workers in Germany are primarily trained through company-based

apprenticeships, the country presents a particularly informative setting for analyzing how firms respond to skilled labor shortages. This sets the present study apart from research on skilled labor shortages in e.g. the U.S. where skills are typically measured by academic degrees.

However, it is not only the structure of the German apprenticeship system but also the dynamics of the labor market that make Germany a particularly interesting case for understanding how companies respond to skilled labor shortages. Labor market data suggests that in Germany skilled labor shortages are more pressing than general labor market tightness. Between 2014 and 2023, the overall unemployment rate averaged 5.8 % (BA [2025b]), remaining above the full employment threshold of 3 %. Unemployment was particularly high among unskilled workers (19.7 %) compared to those with vocational (3.6 %) or tertiary qualifications (2.4 %) (BA [2024a]).[2] Over this period, the gap between skilled and unskilled workers has even widened, with unskilled workers' unemployment reaching 20.8 % in 2023, while unemployment among medium and high-skilled workers remained below the 2015 to 2023 average. Unemployment rates for skilled workers also vary considerably by occupation. In 2023, the highest unemployment rates were in performing arts and entertainment (11.2 %), followed by textile and leather manufacturing (8.5 %). By contrast, skilled workers in financial services (1.0 %) and law/public administration (1.1 %, BA [2023]) had the lowest unemployment rates. Thus, even in occupations with the highest skilled worker unemployment rates, these rates remain substantially lower than those for unskilled workers. When setting the skill-level-specific counts of unemployed jobseekers (BA [2025b]) in relation to job vacancies requiring the same skill level (Institute for Employment Research (IAB) [2024]), there were some 3.4 unskilled workers, 0.9 vocationally trained workers and 0.7 workers with tertiary qualifications per vacancy (see also Section 4). Given the large unemployment gap between skilled and unskilled workers, one might expect unskilled workers to seek vocational training and for companies to invest in training them for skilled positions. However, this development cannot be observed, at least not at the macro level, as Germany has faced an increase in the number of 15-24-year olds classified as NEET (Not in Education, Employment, or Training). This suggests that the potential of unskilled youth remains largely untapped, even as skilled labor shortages increase.

3 Methodology

To estimate the relationship between skilled labor shortages and apprenticeship market outcomes, this paper employs a two-way fixed effects (TWFE) model:

$$Y_{ijt} = \beta W_{ij(t-1)} + \gamma X_{jt} + o_i + r_j + y_t + \epsilon_{ijt}$$

[2]The reported qualification-specific unemployment rates are the average rates between 2015 and 2023, as data for 2014 is unavailable.

where Y_{ijt} represents the outcome of interest (i.e., the number of newly commenced apprenticeships, the number of apprenticeship postings, the share of newly commencing apprentices with a specific school-leaving certificate or the number of prematurely terminated contracts) in occupation i, region j and year t. On the right-hand side, $W_{ij(t-1)}$ denotes the respective skilled labor shortage indicator at the occupation $\times$ region level, measured one year earlier than the outcome at time $t-1$. Furthermore, the model includes occupation fixed effects o_i, region fixed effects r_j, and year fixed effects y_t, as well as region-specific control variables X_{jt}. These control variables include the number of companies per region and the regional GDP in year $t-1$ as well as the number of school leavers in t. For estimating the relationship between skilled labor shortages and the share of newly commencing apprentices with a specific school-leaving certificate, X_{jt} furthermore includes the share of school leavers in the region with an upper secondary diploma and of those with an intermediate secondary diploma.

The inclusion of occupation, region, and time fixed effects controls for unobserved confounders specific to each occupation, region, and time period. Since the outcome development may not be independent across occupations within the same region and within the same occupation across different regions, I cluster the standard errors by region $\times$ occupation. The model is estimated using fixed effects regression.[3]

The TWFE approach estimates the relationship between skilled labor shortage in one year and the apprenticeship market in the following year rather than the average treatment effect of skilled labor shortages, unless some very strict assumptions are imposed. When using a TWFE approach with a non-binary treatment that can increase or decrease over time, as is the case here, several conditions must be met for the estimate to accurately reflect the average treatment effect: for one, the treatment effect must be homogeneous across all regions, occupations and years. Secondly, the parallel trend assumption must hold, i.e. the outcomes would have developed in parallel if the treatment variable did not change over time. Finally, the effects must be linearly additive (Imai and Kim [2021]).

Therefore, I also apply a more robust Difference-in-Differences (DiD) approach developed by de Chaisemartin et al. [2024]. This method estimates the effects of a continuous treatment variable without requiring assumptions of homogeneous treatment effects or linearity. Furthermore, it allows the treatment value to change for all observations between periods, which applies to nearly all observations across all model specifications in this study. The treatment effect is estimated by calculating the average change in outcomes for units experiencing different treatment changes, using quasi-stayers (observations with very small treatment changes) as a reference group to approximate untreated observations. However, the current Stata implementation of this approach does not yet support the inclusion of control variables.

Even with this more robust approach, however, the estimation still faces an endogeneity

[3]For all model specifications considered, the Hausman test indicates that a fixed effects model is preferred over a random effects model.

problem. For this reason, I opt for a more reserved interpretation, considering the estimates as indicative of the relationship between skilled labor shortage and the respective outcome rather than as causal effects. Skilled labor shortages are likely to decrease when companies in a region close or scale down, leading to employee layoffs. While this effect can be partially controlled for by including GDP per capita and the number of companies per region, these controls likely do not fully capture the underlying dynamics. Another source of endogeneity is that economic growth in a region is likely to contribute to skilled labor shortages while also increasing the demand for apprentices. Again, controlling for GDP per capita may help account for this to some extent but is unlikely to fully resolve the issue. Both of these potential sources of endogeneity could lead to an overestimation of the effect.

In addition to GDP and the number of companies in a region, the number of school leavers likely influences the number of newly commenced apprenticeships. Therefore, I include this variable as a control in the estimation of the relationship between skilled labor shortage and apprenticeship counts to reduce noise. Likewise, when estimating the relationship between skilled labor shortages and the school-leaving certificates of the hired apprentices, I account for the available supply of potential apprentices by incorporating the share of school leavers with upper and intermediate secondary diplomas into the estimation.

The model is first estimated for all occupations at once. Additionally, I estimate the model for a subset of six subgroups of occupations and include interaction terms between the skilled labor shortage indicator and dummy variables for these subgroups in order to identify potential heterogeneities in the relationship between skilled labor shortages and the outcomes. The selected groups of occupations are: occupations in (i) retail sales, (ii) mechanical and automotive engineering, (iii) business management and organization, (iv) healthcare, (v) traffic and logistics and (vi) agriculture and forestry. The first five groups of occupations are among those with the highest number of apprenticeships between 2014 and 2023.[4] As a sixth group, I include agriculture and forestry, despite having relatively fewer apprentices, to ensure coverage across all major sectors.

The hypothesis under investigation is that companies increase the number of apprenticeship positions and become less demanding regarding the initial skills of apprentices when facing an increased skilled labor shortage, resulting in more newly started apprentices with, on average, lower educational attainment. For the final outcome analyzed, the share of prematurely terminated contracts, it is unknown whether the termination was initiated by the company or the apprentice. The hypothesis about the relationship between skilled labor shortages and prematurely terminated contracts could go in either direction. On the one hand, apprentices may choose to continue their apprenticeships despite doubts, as skilled labor shortages improve their chances of securing a favorable job after completing their training. Likewise,

[4]Occupations are classified according to the German Classification of Occupations 2010, for more on this see Section 4.1. The first five groups are among the top six occupations in terms of apprenticeship counts. I exclude only the group of mechatronics, energy electronics, and electrical engineering from this top-six list due to its similarity to (ii) mechanical and automotive engineering.

companies facing shortages may retain apprentices despite concerns about their suitability and create an environment that encourages them to stay. On the other hand, if companies lower their hiring standards due to skilled labor shortages, they may ultimately have to let go of more apprentices they initially hired despite reservations. Regarding heterogeneities, I hypothesise that the relationship between skilled labor shortages and the outcomes is stronger when the occupational main group experiences severe skilled labor shortages.

4 Data

4.1 Skilled Labor Shortages

In order to quantify the degree of skilled labor shortages at the regional and occupation level, I rely on the region- and occupation-specific data on unemployment and vacancies provided by the BA [2025a] for a first analysis, as well as the skilled labor shortage score also available from the BA [2024b]. Occupations are classified according to the German Classification of Occupations 2010 (KldB 2010, BA [2020]), a classification scheme that groups occupations based on their similarity in terms of tasks, skills and expertise. The hierarchical structure of the KldB 2010 classification scheme groups occupations at different levels of granularity. For the following analyses, I focus on the hierarchical level of occupational main groups, which distinguishes 35 types of occupations at the skilled worker level, and occupational groups, which identify 103 groups of skilled worker occupations.

In the first analysis, I quantify the level of skilled labor shortages by calculating the ratio of unemployed skilled jobseekers to vacancies that require the same skill at the level of the state × occupational (main) group. Since 2011, the BA [2025a] has published monthly data on the number of unemployed skilled jobseekers and vacancies for each occupational (main) group across all 16 German states. I compute the ratio of unemployed skilled jobseekers to vacancies using the current stock of jobseekers and vacancies measured each September from 2013 to 2022. [5] By using the September data, I can link the skilled labor shortages in year t–1 to apprenticeships starting one year later, in August or September of year t.[6]

In the first specification, I estimate the relationship between skilled labor shortages and the apprenticeship market at the occupational main group level, distinguishing 35 occupations. I then conduct a second analysis at the occupational group level, which differentiates 103 specific types of skilled occupations. However, at this more detailed level, some occupational groups may be similar enough that an unemployed jobseeker trained in one occupation could

[5] In these datasets, values of 1 or 2 are anonymized; I set these values to 1.5. The ratio is calculated as the number of unemployed jobseekers plus one divided by the number of vacancies plus one in order to ensure that the ratio is defined even in the rare case of zero vacancies for a given occupation, state and year.

[6] At the time the ratio is measured, the vast majority of companies have not yet announced their apprenticeship positions for the following year; these are typically published between October and January. Application deadlines for most apprenticeship positions fall between November and March, though companies continue to fill vacant positions throughout the summer (Azubiyo [2025]).

also be well-suited for positions in other related occupational groups. As a result, the ratio of unemployed skilled jobseekers to vacancies at the occupational group level may partially overestimate the actual skilled labor shortages companies experience. Additionally, the extent to which workers can transition between occupations likely varies across industries, further influencing the accuracy of this measure.

In a third analysis, I use an indicator constructed by the Federal Employment Agency based on six statistical measures, all evaluated at the occupation × state[7] level. These indicators include the median vacancy duration, the ratio of jobseekers to vacancies, the unemployment rate, the exit rate from unemployment, as well as the change in the share of social security-covered foreign workers and the growth rate of median wages over the last three years leading up to the reporting year.[8] For each indicator, the BA has established a set of thresholds based on which it assigns a score ranging from 0 (very far from signs of a skilled labor shortage) to 3 (clear signs of a shortage). These six scores are averaged to obtain a single overall score that reflects the skilled labor shortage for a given state and occupation, with this score ranging from 0 to 3 and higher values indicating a more severe skilled labor shortage in the respective state and occupation. To improve the interpretability of the estimation results, I rescale the BA skilled labor shortage indicator to range from 0 to 100,, where lower values indicate more severe skilled labor shortages. This makes it comparable to the unemployed jobseeker-to-vacancy ratio, which also reflects a greater shortage of skilled labor when the value is lower.

While representing a rare comprehensive indicator of skilled labor shortages at the occupational group × state level, the BA [2024b] skilled-labor-shortage score has several limitations. For one, it is only available for years since 2020, resulting in a relatively short observation period that coincides with the Covid-19 pandemic. Then, it is reported only at the occupational group level and is unavailable for many less common occupational groups, particularly in smaller states, due to data availability requirements.[9] In contrast, the ratio of vacancies to unemployed jobseekers is available for all occupations and states. Finally, since the skilled-labor-shortage score captures, among other factors, the development of median wages and the share of foreign workers, it reflects not only the current mismatch between skilled labor supply and demand, but also how companies are adapting to it.

The BA maintains occupation-specific unemployment data because it records which occupation each unemployed person is aiming for. This target occupation is determined during

[7]To enhance the availability of robust data, the three city-states — Berlin, Hamburg, and Bremen — are combined with neighboring non-city states. Additionally, the two comparably small states of Saarland and Rhineland-Palatinate in southwest Germany are grouped together, so that the score is calculated for 12 geographic entities. For simplicity, I will refer to these entities as states.

[8]Unemployment and registered job openings are measured as annual averages. Employment of foreign workers is recorded on June 30 of the reporting year and three years before, while wages are measured on December 31 of the reporting year and three years prior to it.

[9]It is only reported if there are at least 500 employees subject to social insurance contributions in this occupation and state, at least four out of the six included measures are available, and one of the evaluated indicators is the vacancy duration.

counseling sessions at an employment agency or job center, taking into account the individual's qualifications, suitability, preferences and chances of finding employment in that specific occupation. The target occupation may differ from the individual's trained profession and the person's most recent job (BA [2019b]). Since the target occupation reflects the preferences and qualifications of the unemployed jobseeker, the occupation-specific unemployment data from the BA largely captures the skilled labor supply as defined in this study's concept of skilled labor shortages (Shah and Burke [2005]). The only factor not taken into account is that some individuals may not be willing or able to take a job, but are required to register a target occupation in order to qualify for unemployment benefits.

Furthermore, as most occupations have closely related alternatives, it should be noted that while the target occupation represents the primary aspired position of the unemployed individual, the BA also registers more or less related alternative occupations - in 2017, that was the case for about 60 % of the unemployed (BA [2019b]). In addition, of course, the unemployed may also apply for vacancies that are neither registered as a target occupation nor as an alternative occupation. On the other hand, companies looking for employees in a given occupation may employ individuals for whom the given occupation is not their target occupation but who apply anyway. An analysis of the BA [2019b] on the occupational mobility of unemployed individuals shows that 58 % of unemployed persons who were looking for an occupation at the skilled worker level and took up employment in 2017 started a job that did not correspond either to their target occupation or to their target qualification level[10]. Therefore, the actual skilled labor supply available to companies looking to fill a position is often larger than the number of unemployed skilled jobseekers registered by the BA for that specific occupation. However, in this study, I focus on relatively broad groups of occupations and the mobility between different groups naturally decreases as the level of aggregation increases, which should account for much of this cross-occupation mobility. The remaining mobility across groups will be more of a concern in the analyses at the occupational group level that differentiate between 103 occupational groups, compared to those that distinguish 35 occupational main groups, although, even in the latter case, considerable occupational mobility still exists according to the BA [2019a]. For the present study, this only becomes problematic if there are systematic differences between regions and/or occupations in how the share of applications from suitable unemployed individuals with a deviating target occupation changes over time.

The vacancy data includes all vacancies for jobs subject to social security contributions, part-time jobs and other jobs with an intended duration of more than seven days that are reported to the BA for placement services. Companies are not obliged to register their vacancies with the BA. Estimates suggest that some 40 to 50 % of vacancies at the skilled worker level are

[10]The BA distinguishes four skill levels. In addition to skilled workers — defined as individuals who have completed at least two years of vocational training but do not possess a college or university degree, a Meister qualification, or an equivalent credential — who are the focus of this study, there are unskilled workers, specialists, and experts (BA [2025c]).

registered with the BA (Burstedde et al. [2020]), while the rest are advertised through other channels or filled in-house. Again, the under-reporting of vacancies is only problematic if the development of the reporting behavior of companies varies systematically across occupations and regions.

4.2 Apprenticeship Market

To measure the demand for apprentices and the expectations employers have for apprentices in different occupations and regions, I use annual register data on apprenticeship contracts (Berufsbildungsstatistik der Statistischen Ämter des Bundes und der Länder, BBS) and data on apprenticeship postings provided by the BA.

The BBS data contains information on all apprenticeships that were started, ongoing, successfully completed or prematurely terminated in Germany each year. This data is reported by the training companies to the regional chambers, collected by the Federal Office of Statistics and processed by the Federal Institute for Vocational Education and Training (Bundesinstitut für Berufsbildung, BIBB). Since all companies are obliged to report the requested details for each apprentice they contract, the dataset has the character of administrative register data. The data contains, among other details, information on the location of the training company, the apprentice's training occupation classified based on the KldB 2010 classification[11], the school-leaving qualification of employed apprentices and on whether the apprenticeship contract was prematurely terminated[12]. Thus, five outcomes can be derived from the BBS data: the number of newly started apprenticeships, the share of employed apprentices with lower, intermediate, and higher secondary degrees, and the number of contracts terminated prematurely, each by occupational (main) group and state. In addition to the outcomes derived from the BBS data, I use data on the number of apprenticeship postings registered with the employment agencies and job centers in order to quantify the demand for apprentices. This data is collected by the BA and is available by year, region and different KldB 2010 levels. [13]

[11]Note that the KldB 2010 is a general, not-apprenticeship-specific, classification scheme. Some of the 327 government-recognized apprenticeship occupations may fall into different KldB 2010 categories depending on the sector in which the company operates and the specialization it consequently trains its apprentices in. For example, a digital and print media design apprentice may either be assigned to the KldB 2010 category of "occupations in sales" or "occupations in digital and print media design", depending on whether the focus of the training is on consulting and planning or on conception, design and visualization.

[12]For contracts scheduled to begin in a given year, it is only possible to determine whether they were terminated before the end of that same year. However, it is not known whether the termination was initiated by the apprentice or the employer. Since the probationary period for apprenticeships cannot exceed four months and the vast majority of apprenticeships start on August 1 or September 1, most terminations during this period are captured. After the probationary period ends, an apprentice may only be dismissed by the employer in cases of serious violations of the apprenticeship agreement (§ 22(2)(1) BBiG). However, the apprentice may still terminate the apprenticeship at any time.

[13]To obtain state-level data for the initial analyses involving the ratio of unemployed skilled jobseekers to vacancies from 2013 to 2022, I aggregate district × occupational main group data on apprenticeship postings provided by the BA. The data at the district × occupational group level contains too many anonymized

The apprenticeship posting counts include all apprenticeship postings reported to the BA for advertising and candidate matching. Since companies are not required to register their apprenticeships with the BA, these counts do not reflect the actual number of apprenticeship postings. However, according to the BA, approximately 75 % of all apprenticeship postings are registered, and this share has remained constant throughout the study period (BA, personal communication, June 19, 2024).[14]

The data on skilled labor shortages, demand for apprentices, and companies' expectations for apprentices is combined with a set of regional control variables, namely regional GDP, the number of companies and the number of school leavers per state and year, provided by the Federal Statistics Office. For the analyses involving the share of apprentices with different school-leaving certificates, I also include data from the Federal Statistics Office on the shares of school leavers by certificate type.

4.3 Descriptive Statistics

Figure 1 illustrates the development of the ratio of unemployed skilled jobseekers to vacancies by occupational sector from 2013 to 2022. The figure shows that the number of unemployed skilled jobseekers per vacancy declined in nearly every occupational sector between 2013 and 2019, indicating a growing skilled labor shortage. In 2020, all sectors experienced a temporary spike, likely due to the COVID-19 pandemic, before returning to pre-pandemic levels in most cases.[15] While nearly all occupational sectors saw a decrease in the unemployed-skilled-jobseeker-to-vacancy ratio, there were significant differences in the extent to which this ratio declined over the observation period. Some occupational sectors, such as production and manufacturing as well as healthcare and education, were already experiencing a moderate skilled labor shortage in 2013, with approximately two unemployed skilled jobseekers per vacancy. In contrast, occupations in administration and finance, transport and security as

values, which is why the relationship between the ratio and apprenticeship postings at the occupational group level will not be analyzed. For the period from 2020 to 2022, BA [2025d] also provides data on registered apprenticeship postings at the state × occupational group level, which I use for the analysis involving the BA skilled labor shortage indicator. For data protection reasons, the exact number of apprenticeship postings is not disclosed in either dataset if there are only one or two postings in a given occupation and region. Additionally, in rare cases, other values may be anonymized to prevent the back-calculation of missing data. In such cases, the missing values can be approximated using additional contextual information.

[14] Unlike the skilled labor shortage indicators and outcomes derived from the BBS data, which are based on calendar years, the reporting period for the BA apprenticeship posting data is October 1 to September 30 of the following year. Since the vast majority of apprenticeships begin in August or September, according to the BA only 12,100 apprenticeship positions with a scheduled start in 2023 were registered after September 30, 2023. Most of these had already been filled earlier in 2023 and were re-registered due to early contract terminations (BA [2024c]), with a similar number of newly registered positions in previous years. By comparison, 511,799 apprenticeships scheduled to start in 2023 were registered before September 30, 2023, making the number of apprenticeship postings registered for the first time after this date negligible. Thus, the registered apprenticeship postings from October 1 of one year to September 30 of the next year largely coincide with the apprenticeship postings in the calendar year spanning January 1 to December 31 of this latter year.

[15] The Humanities and Arts sector did not experience a decline in the ratio of unemployed skilled jobseekers to vacancies. However, this sector plays only a minor role in vocational training.

well as commerce and hospitality had significantly higher ratios of 7.5, 6.1, and 5.3 unemployed skilled jobseekers per vacancy, respectively. By 2022, the ratio in all three of these sectors had dropped below 2, reaching a level similar to that of science and IT, which had experienced much less of an increase in skilled labor shortage over the period and had a ratio only half as high as the other three in 2014. These differences in the development of skilled labor shortages across occupational sectors bring about valuable variation for the TWFE estimation.

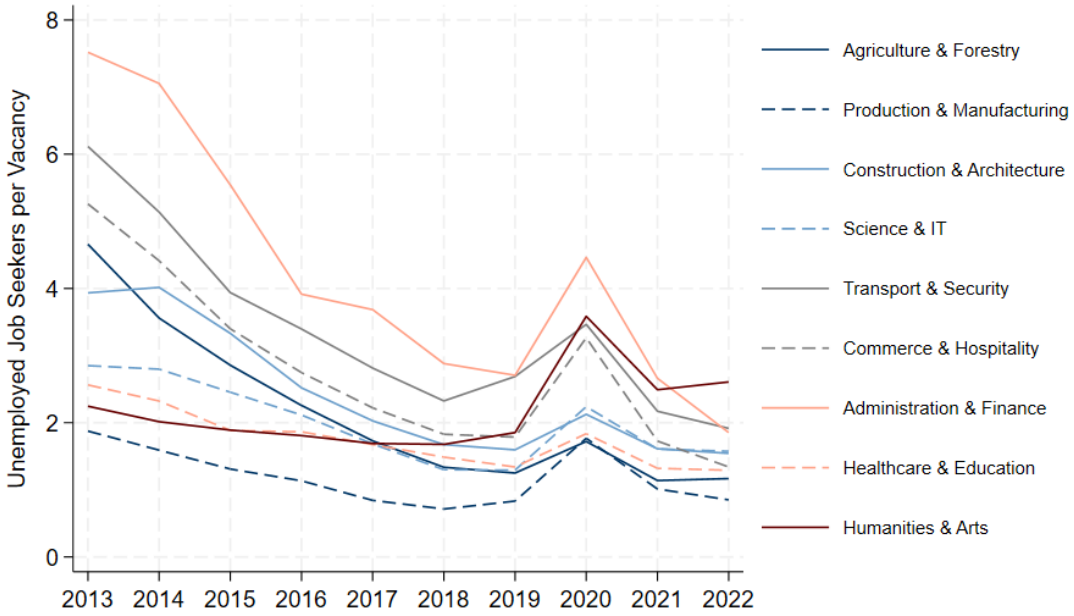

Figure 1: Development of the ratio of unemployed jobseekers to vacancies per occupational area from 2014 to 2023.

Figures A.1 to A.6 in the appendix show the geographical distribution of the ratio of unemployed jobseekers to vacancies in the six occupational main groups assessed in detail in the analysis. These figures reveal not only varying developments over time for the different occupational main groups, but also substantial differences in the geographical distribution of skilled labor shortages. In 2013, there was a clear tendency for a greater surplus of unemployed skilled jobseekers in Eastern Germany compared particularly to the South of Germany where there were partly some skilled labor shortages observable already. By 2022, these regional differences had become less pronounced. Instead, in four out of the six occupational main groups there were severe skilled labor shortages across all states in 2022. Only for occupations in business management and organization (Figure A.5) as well as in agriculture, forestry, and farming (Figure A.1), there were no regions with less than 1.25 unemployed skilled jobseekers per vacancy, again without a clear divide between Eastern and Western or South and North Germany. The lowest ratio of unemployed skilled jobseekers to vacancies can be observed in medical and health care occupations (Figure A.6), technical occupations in the machine-building and automotive industry (Figure A.2) and occupations

in traffic and logistics (A.3). Notably, the first two of these occupational groups had already been experiencing a moderate skilled labor shortage across large parts of Germany as early as 2013. These geographical differences in the development of skilled labor shortages serve as another key source of variation for the TWFE estimation.

Figure 2 illustrates the development of the key outcome variable, the number of newly commenced apprenticeships, by occupational sector. The development of the other outcome variables is shown in figures A.7 to A.11 in the appendix. The impact of the Covid-19 pandemic on newly commenced apprenticeships was relatively mild, with only a small decline in newly commenced apprenticeships in 2020. This contrasts with the broader labor market, where the economic downturn led to reduced demand for skilled labor and, in some cases, layoffs, as reflected in the increase in skilled jobseekers per vacancy (see Figure 1). The differences in how the skilled labor shortage indicator and the apprenticeship market responded to the Covid-19 pandemic may only introduce some additional noise into the estimation, as long as there are no systematic differences across occupational groups and states in how the pandemic affected these measures. The trend in apprenticeship postings followed a similar pattern to that of newly commenced apprenticeships (see Figure A.7).

Regarding the educational background of newly enrolled apprentices, figures A.8, A.9, and A.10 reveal severe differences across occupational sectors in both the composition of apprentices by school leaving certificate and how it has changed over time. Figure A.8 shows that the proportion of new apprentices with a higher secondary education degree is much higher in occupations related to humanities and arts, science and IT, as well as administration and finance than in other sectors. In these three fields, the share of apprentices with a higher secondary degree increased during the first half of the study period but began to decline after 2021. In most other occupational sectors, the share of apprentices with a higher and/or intermediate secondary degree increased throughout the whole study period, with this trend being particularly pronounced in the construction and architecture sector - the sector with the highest proportion of apprentices holding a lower secondary degree. Overall, the differences in the educational composition of apprentices across occupational sectors have narrowed over time. Finally, the share of prematurely terminated contracts also varies significantly between occupational sectors but has steadily increased across all sectors throughout the study period.

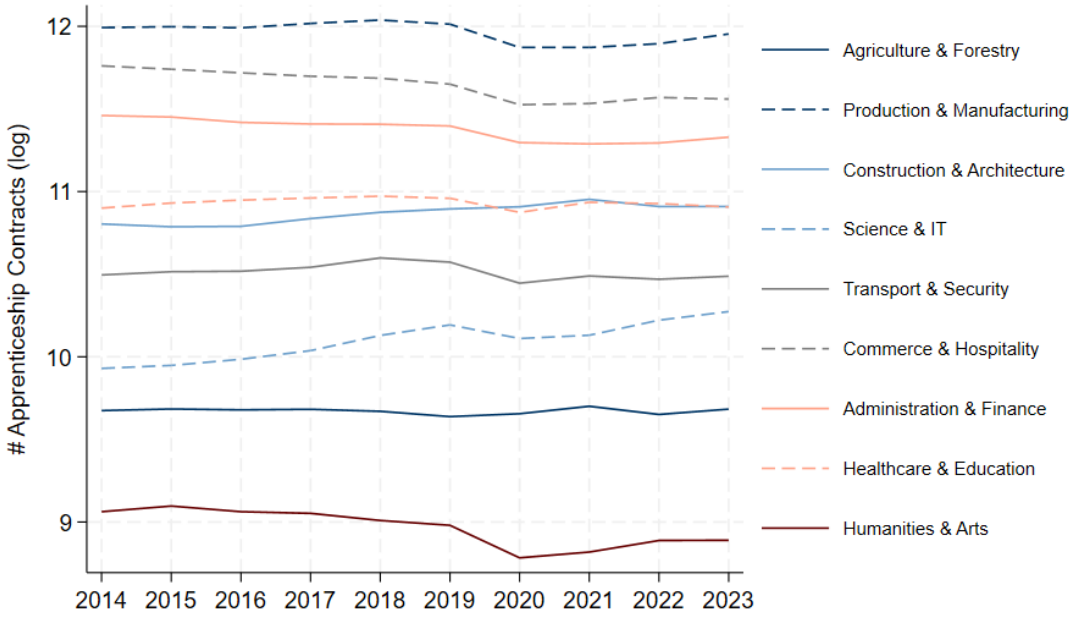

Figure 2: Development of the number of newly commenced apprenticeships per occupational sector from 2014 to 2023.

Tables 1 and 2 summarize the values for all treatment, outcome, and control variables in this study. The first table presents national averages for Germany, with observations weighted by the size of the state and occupational group. For variables that represent absolute quantities, such as the number of apprentices, the table provides total figures - for example, the total number of apprenticeships across the country. In contrast, the second table displays unweighted averages at the state × occupational main group level, except for the BA shortage score, which is calculated at the state × occupational group level. The selected years correspond to the starting years of the two treatment variables as well as the final year of the observation period. In most variables, the impact of the COVID-19 downturn in 2020/21 is clearly noticeable.

Labor Shortage Indicators	**2013**	**2020**	**2022**
Unemployed jobseekers to Vacancies	3.66	2.51	1.36
BA Skilled Labor Shortage Indicator		50.4	40.6
Outcomes	**2014**	**2021**	**2023**
Newly Commenced Apprenticeships	569,179	522,477	540,908
Apprenticeship Postings	532,987	522,867	545,039
Apprentices with Higher Secondary Degree [%]	25.3	29.1	27.2
Apprentices with Intermediate Secondary Degree [%]	42.4	42.0	44.0
Apprentices with Lower Secondary Degree [%]	29.3	25.8	25.8
Prematurely Terminated Contracts [%]	8.9	10.4	10.9
Controls	**t: 2014/ t-1: 2013**	**t: 2020/ t-1: 2021**	**t: 2022/ t-1: 2023**
GDP/capita (t-1)	34,869	40,933	46,243
# Companies (t-1)	3,853,716	3,668,276	3,726,781
School Leavers (t)	850,721	768,191	782,423
... with Higher Secondary Degree [%]	33.1	34.4	33.2
... with Intermediate Secondary Degree [%]	44.2	43.5	43.0

Table 1: Treatment, outcome, and control variables at the national level (i.e, weighted arithmetic mean of state × occupation observations) for t = 2014,2021 and 2023.

Labor Shortage Indicators	**2013**	**2020**	**2022**
Unemployed jobseekers to Vacancies	5.74	5.68	3.49
	(7.52)	(12.0)	(11.8)
BA Skilled Labor Shortage Indicator		48.4	40.0
		(20.0)	(18.2)
Outcomes	**2014**	**2021**	**2023**
Newly Commenced Apprenticeships	377.4	340.8	357.3
	(906.8)	(834.0)	(849.1)
Apprenticeship Postings	925.3	908.3	946.8
	(1,734)	(1,771)	(1,856)
Apprentices with Higher Secondary Degree [%]	31.2	36.0	33.1
	(26.8)	(27.3)	(25.9)
Apprentices with Intermediate Secondary Degree [%]	41.6	39.7	42.3
	(20.1)	(19.7)	(19.1)
Apprentices with Lower Secondary Degree [%]	23.6	21.1	21.3
	(22.6)	(20.5)	(20.3)
Prematurely Terminated Contracts [%]	8.5	9.6	10.1
	(9.0)	(9.6)	(10.0)

Table 2: Treatment, outcome, and control variables (unweighted arithmetic mean and standard deviation across all state × occupational main group observations) for t = 2014, 2021 and 2023. Only for the skilled labor shortage score, the descriptive statistics are obtained from the state × occupational group level data.

5 Findings

The results of the main specification, which examines the relationship between the ratio of unemployed skilled jobseekers to vacancies and the apprenticeship market at the state × occupational main group level, are presented in Table 3. While most estimates from the simple TWFE approach, with and without controls, are not statistically significant, they consistently show the expected sign and are at least partially of economically meaningful magnitude.

Specifically, the number of newly commenced apprenticeships declines by approximately 0.3 % for each additional unemployed skilled jobseeker per vacancy in a given occupational main group. The TWFE estimates further suggest that a decrease of one in the number of unemployed skilled workers per vacancy in an occupational main group is associated with a decline of about 0.1 percentage points in the share of apprentices with a higher secondary degree. Conversely, the share of apprentices with an intermediate or lower secondary degree increases as skilled labor shortages grow. The relationship between skilled labor shortages and the share of prematurely terminated contracts, where theoretical considerations suggest that both a positive or negative relationship could be plausible, is estimated to be negative. In other words, as skilled labor shortages increase - quantified as a one-unit decline in the ratio of unemployed skilled jobseekers to vacancies - the share of prematurely terminated contracts decreases by approximately 0.014 percentage points. Although very close to zero, the positive sign suggests that during skilled labor shortages, companies and/or apprentices may be more inclined to continue the apprenticeship. Firms may make greater efforts to retain apprentices even when concerns arise, while apprentices may see better prospects in completing their training.

The estimates from the de Chaisemartin et al. [2024] approach show the same signs as the TWFE estimates but are larger in absolute value and statistically significant. This supports the validity of the TWFE estimates. They suggest that an increase in skilled labor shortages, measured as a one-unit decrease in the ratio of unemployed skilled jobseekers to vacancies in an occupational main group, leads to an increase of about 0.8 % in the number of newly commenced apprenticeships in that group. For the share of apprentices with a higher secondary degree, the estimates predict a decrease of 0.24 percentage points for each one-unit decline in the ratio of unemployed skilled jobseekers per vacancy. Finally, the share of terminated contracts is estimated to decrease by about 0.07 percentage points as skilled labor shortages increase, represented by a one-unit decline in the number of unemployed skilled jobseekers per vacancy.

	Newly Commenced Apprenticeships (log)			Apprenticeship Postings (log)			% Terminated Apprenticeships		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
Unemployed Jobseekers per Vacancy	-.0035*	-.0032	-.0082***	-.0016	-.0016	-.0040**	.0199	.0144	.0650***
(s.e.)	(.0018)	(.0018)	(.0011)	(.0022)	(.0022)	(.0015)	(.0175)	(.0180)	(.0138)
GDP/Capita		✓			✓			✓	
Companies		✓			✓			✓	
# School Leavers		✓			✓			✓	
Year FE	✓	✓	✓	✓	✓	✓	✓	✓	✓
N		5,382			5,382			5,382	

	% Higher Secondary Degree Appr.			% Intermed. Secondary Degree Appr.			% Lower Secondary Degree Appr.		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
Unemployed Jobseekers per Vacancy	.1003*	.0944*	.2352***	-.0883	-.0871	-.1990***	-.0275	-.0182	-.0478*
(s.e.)	(.0412)	(.0417)	(.0257)	(.0484)	(.0495)	(.0236)	(.0293)	(.0289)	(.0239)
GDP/Capita		✓			✓			✓	
Companies		✓			✓			✓	
# School Leavers		✓			✓			✓	
... with Higher Second. Degree [%]		✓			✓			✓	
... with Intermediate Second. Degree [%]		✓			✓			✓	
Year FE	✓	✓	✓	✓	✓	✓	✓	✓	✓
N		5,382			5,382			5,382	

Table 3: Estimation results for the relationship between the ratio of unemployed skilled jobseekers per vacancy and various outcomes at the state × occupational main group level where the estimates are obtained using (1) TWFE with controls and (2) the robust approach developed by de Chaisemartin et al. [2024]. Clustered standard errors at the state × occupational main group level are reported in parentheses. Significance levels: * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

Tables B.1 and B.2 in the appendix present the estimation results for the relationship between the ratio of unemployed skilled jobseekers to vacancies and apprenticeship outcomes, as well as between the BA skilled labor shortage indicator and apprenticeship outcomes, both at the occupational main group × state level. As in Table 3, almost all estimates are of the expected sign. However, the estimated coefficients are generally smaller in absolute value than those at the occupational main group × state level. This may be explained by the fact that, instead of adapting their apprenticeship approaches, companies can circumvent skilled labor shortages in certain occupational groups by hiring workers trained in closely related occupational groups (this is not uncommon as can be seen from the high proportion of unemployed jobseekers who accept a job in an occupation other than their preferred one, see also Section 4.1 for more information).

The only outcome for which the evidence is not entirely consistent is the share of prematurely terminated contracts. While most estimates suggest a negative relationship between skilled labor shortages and the share of prematurely terminated contracts, the de Chaisemartin et al. [2024] estimates for both specifications at the occupational group × state level indicate a positive relationship.

Table 4 presents the heterogeneity estimates from TWFE estimations with controls and

	Apprentices (log)	Postings (log)	Higher Degr. [%]	Interm. Degr. [%]	Lower Degr. [%]	Terminations [%]
Agriculture, Forestry & Farming	-0.0033	0.0057	0.0137	-0.0686	0.0663	0.0644
	(0.0020)	(0.0034)	(0.0872)	(0.0659)	(0.0949)	(0.0599)
Machine-Building &	-0.0608***	-0.0521***	0.6473	0.0561	-0.6011	0.0013
Automotive Industry	(0.0093)	(0.0142)	(0.3464)	(0.3990)	(0.3503)	(0.1384)
Traffic & Logistics	-0.0112*	-0.0348***	0.7049**	-0.9641***	-0.0020	-0.1782
	(0.0050)	(0.0091)	(0.2722)	(0.2309)	(0.2147)	(0.1297)
Retail Sales	0.0050	-0.0335***	0.2122	-0.1714	-0.0989	-0.0887
	(0.0056)	(0.0058)	(0.1260)	(0.1394)	(0.1331)	(0.0552)
Business Management	0.0109***	0.0057	0.3445**	-0.3522***	-0.0823	-0.0250
& Organization	(0.0021)	(0.0032)	(0.1148)	(0.0968)	(0.0584)	(0.0364)
Medical and Healthcare	-0.1333***	-0.1174**	-0.0062	4.6019***	-4.3430***	0.7303
Occupations	(0.0152)	(0.0405)	(0.4665)	(1.0990)	(1.0186)	(0.4556)
GDP/Capita	✓	✓	✓	✓	✓	✓
Companies	✓	✓	✓	✓	✓	✓
# School Leavers	✓	✓	✓	✓	✓	✓
... with Higher Degree [%]			✓	✓	✓	
... with Interm. Degree [%]			✓	✓	✓	
Year FE	✓	✓	✓	✓	✓	✓
N	952	952	952	952	952	952

Table 4: Heterogeneity estimates from TWFE estimations with controls and interactions between the ratio of unemployed skilled jobseekers to vacancies and dummy variables for the six occupational main groups under specific examination. The estimations are conducted on state × occupational main group data for the six occupational main groups under study. Clustered standard errors at the state × occupational main group level are reported in parentheses. Significance levels: * p < 0.05; ** p < 0.01; *** p < 0.001.

interactions between the ratio of unemployed skilled jobseekers to vacancies and dummy variables for the six occupational main groups under specific examination, performed using state × occupational main group data.

The estimates show that the positive relationship between skilled labor shortages and the number of newly commenced apprenticeships is strongest in medical and healthcare occupations, as well as in technical occupations related to machine building and the automotive industry. In these fields, a one-unit decline in the ratio of unemployed skilled jobseekers to vacancies is associated with an estimated increase in newly commenced apprenticeships of 12.5 % and 6 %, respectively. In contrast, no such increase in apprenticeship hires is observed in business management and organization or retail trade. In fact, for these two occupational groups, the estimates suggest the opposite trend. However, these two occupational groups experienced relatively lower levels of skilled labor shortages, as shown in Figures A.5 and A.4 in the appendix. This suggests that the positive relationship between skilled labor shortages and the number of newly commencing apprenticeships may only emerge once a certain level of skilled labor shortage is reached. The relationship between skilled labor shortages and apprenticeship postings follows a similar pattern to that of newly commenced apprenticeships. Notably, there is also a significant increase in apprenticeship postings associated with rising skilled labor shortages in retail sales.

Regarding the educational attainment of new apprentices, the results indicate that in almost all examined occupations, the share of newly signed apprentices with a higher secondary education degree decreases in response to skilled labor shortages - often substantially and statistically significantly. The only exception is in medical and healthcare occupations, where there is rather a shift from hiring apprentices with intermediate secondary degrees to hiring those with lower secondary degrees in response to skilled labor shortages - and this shift is of considerable size.

Finally, when analyzing the relationship between skilled labor shortages and premature contract terminations, the results suggest that in medical and healthcare occupations, higher skilled labor shortages tend to be associated with a lower share of contract terminations. Conversely, in traffic and logistics occupations, the opposite relationship is observed. In all other occupational groups, the estimates are close to zero. However, none of these estimates are statistically significant.

6 Conclusion

In this study, I assess the relationship between skilled labor shortages and companies' apprenticeship practices. Skilled labor shortages are measured using two approaches: the ratio of unemployed skilled jobseekers to vacancies and a skilled labor shortage indicator developed by the BA that is calculated based on median vacancy duration, the jobseeker-to-vacancy ratio, the unemployment rate, the unemployment exit rate, changes in the share of foreign

workers, and median wage growth. Both measures quantify skilled labor shortages by occupational group and state, so that I can leverage regional as well as occupational differences in the development of skilled labor shortages in different TWFE estimations and a robust DiD approach as developed by de Chaisemartin et al. [2024].

The estimation results reveal that increased skilled labor shortages tend to bring about a higher demand for apprentices and more new apprentice hires in occupations experiencing shortages. Additionally, companies facing greater skilled labor shortages tend to hire apprentices with lower educational qualifications. The relationship between skilled labor shortages and premature contract terminations, however, remains ambiguous.

An analysis of heterogeneities in the relationship between skilled labor shortages and apprenticeship dynamics reveals notable differences across occupations. In particular, for occupations with relatively low levels of skilled labor shortages, the observed relationships partly differ from expectations both in magnitude and direction, potentially indicating that companies only adjust their apprenticeship practices in response to severe shortages.

These findings open several avenues for further research, particularly through the use of natural experiments. For example, the skilled labor shortage measures used in this study could be instrumented by factors such as company bankruptcies or mass layoffs that primarily affect specific regions and occupations. Additionally, certain policy measures that influence labor demand or supply in specific occupations, such as the German Heating Act, could serve as suitable instruments for further analysis.

Companies' tendency to mitigate skilled labor shortages by training more apprentices, including those with lower formal qualifications, underscores the importance of vocational training in securing future skilled labor supply. With demographic change continuing to limit skilled labor availability, apprenticeship training is likely to remain key, making it crucial for policymakers to support and enhance the apprenticeship system.

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A Descriptive Statistics

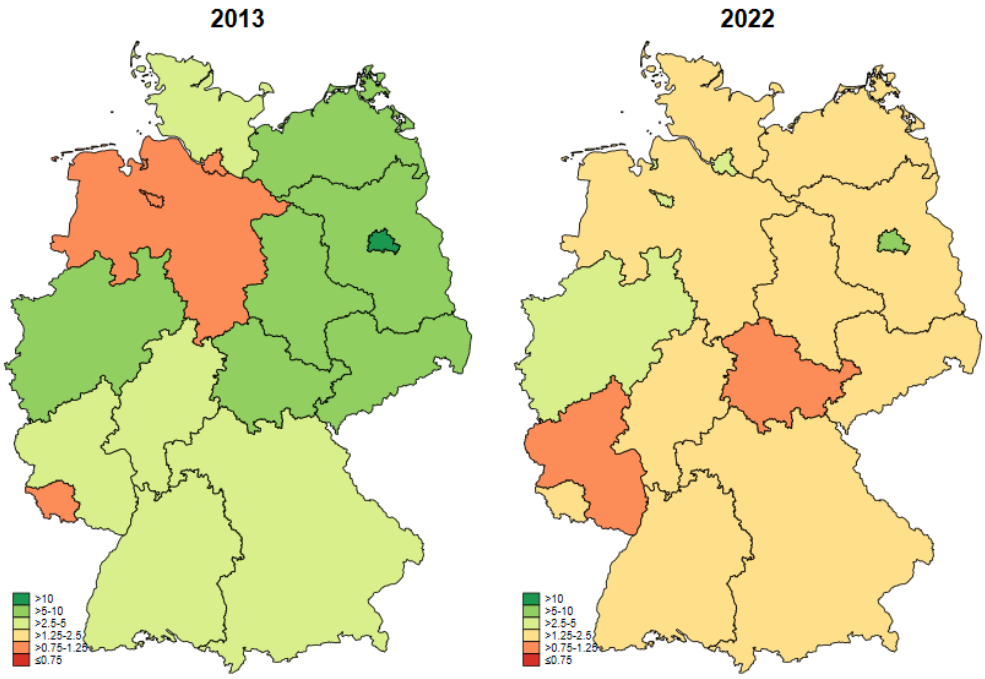

Figure A.1: Geographical distribution of the number of unemployed jobseekers per vacancy in occupations in agriculture, forestry, and farming, 2013 and 2022.

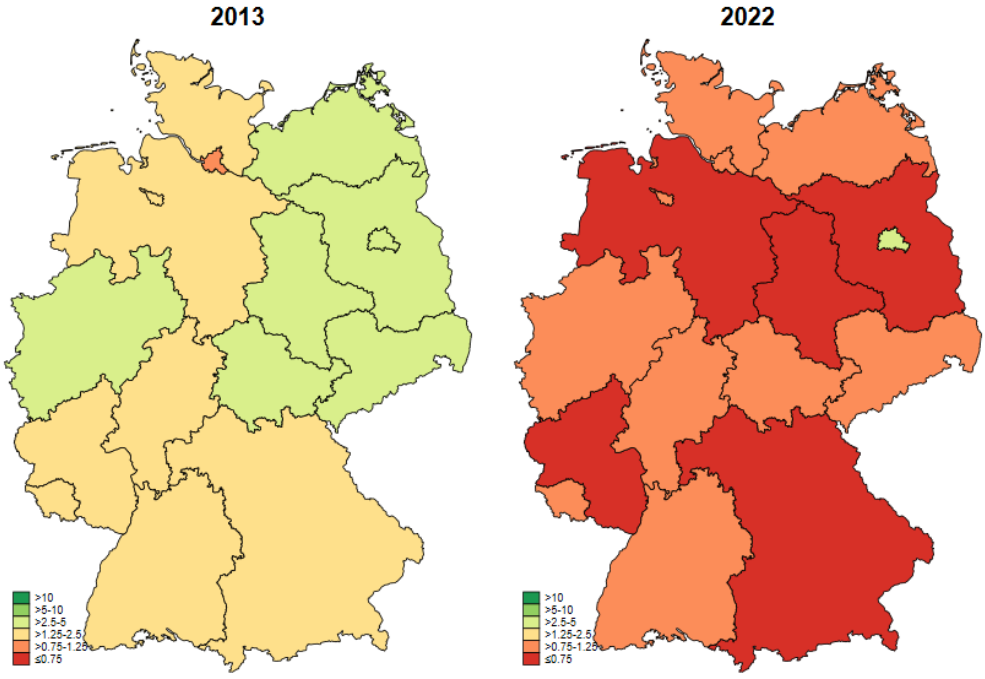

Figure A.2: Geographical distribution of the number of unemployed jobseekers per vacancy in technical occupations in the machine-building and automotive industry, 2013 and 2022.

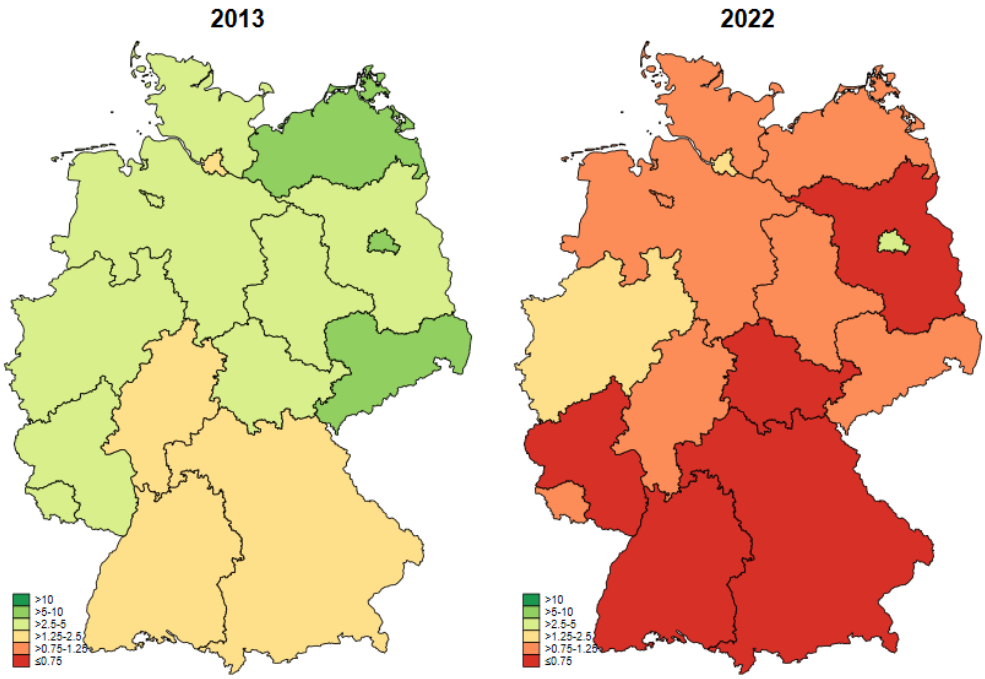

Figure A.3: Geographical distribution of the number of unemployed jobseekers per vacancy in occupations in traffic and logistics (without vehicle driving), 2013 and 2022.

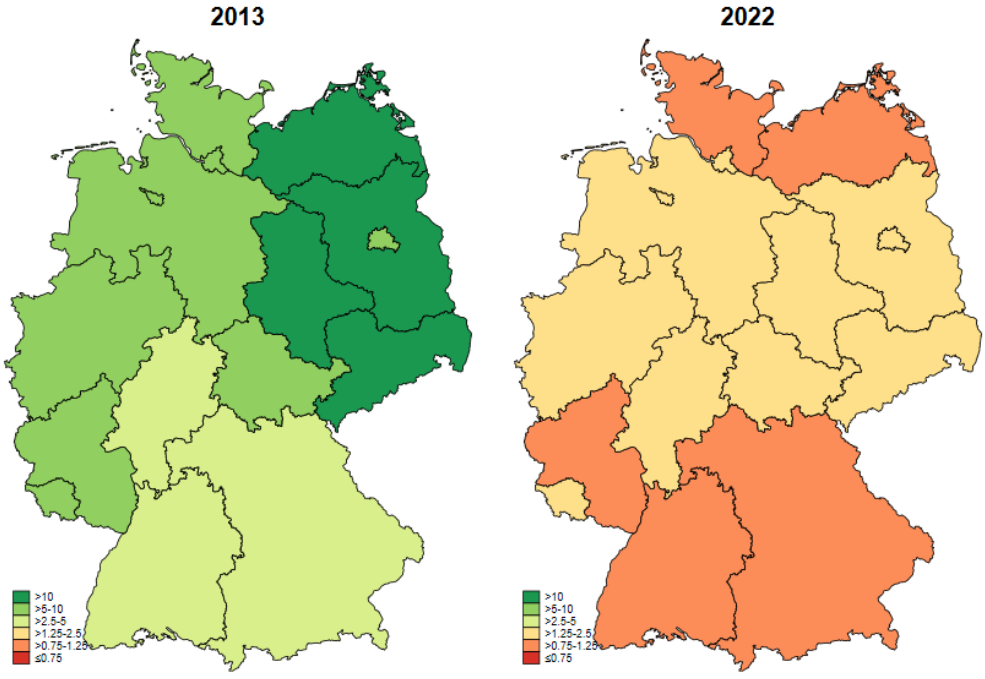

Figure A.4: Geographical distribution of the number of unemployed jobseekers per vacancy in sales occupations in retail trade, 2013 and 2022.

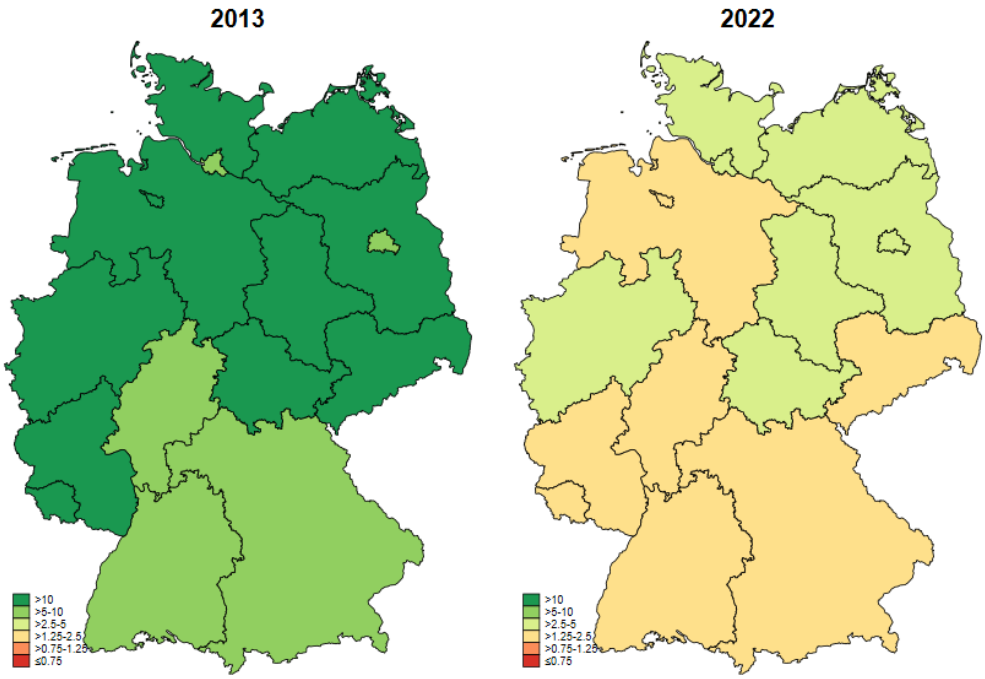

Figure A.5: Geographical distribution of the number of unemployed jobseekers per vacancy in occupations in business management and organization, 2013 and 2022.

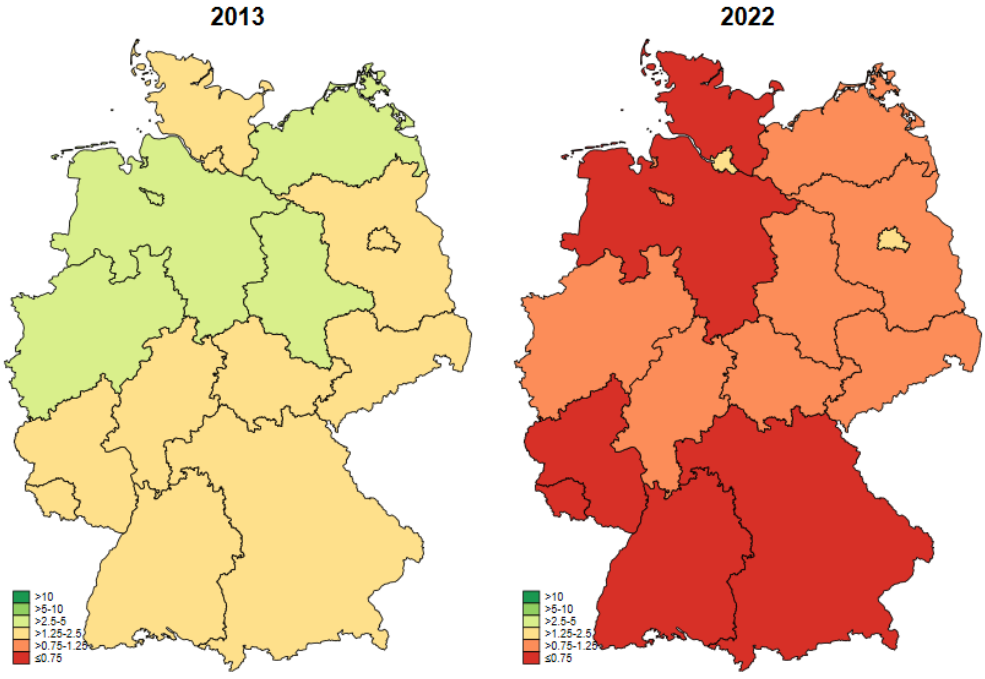

Figure A.6: Geographical distribution of the number of unemployed jobseekers per vacancy in medical and health care occupations, 2013 and 2022.

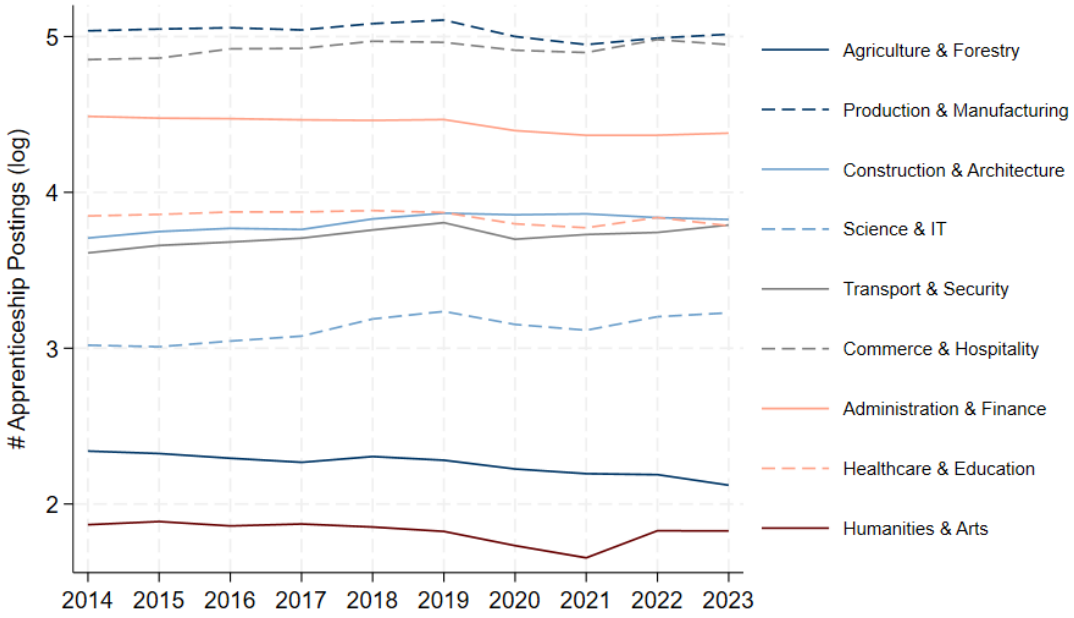

Figure A.7: Development of the number of yearly apprenticeship postings per occupational area from 2014 to 2023.

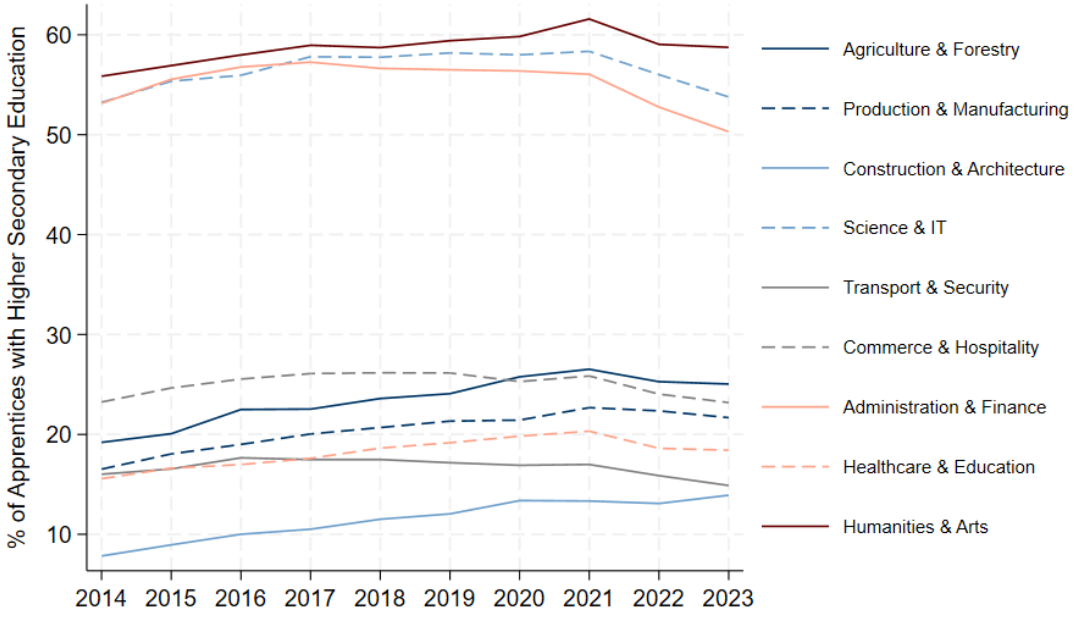

Figure A.8: Development of the share of newly commencing apprentices with a higher secondary degree per occupational area from 2013 to 2022.

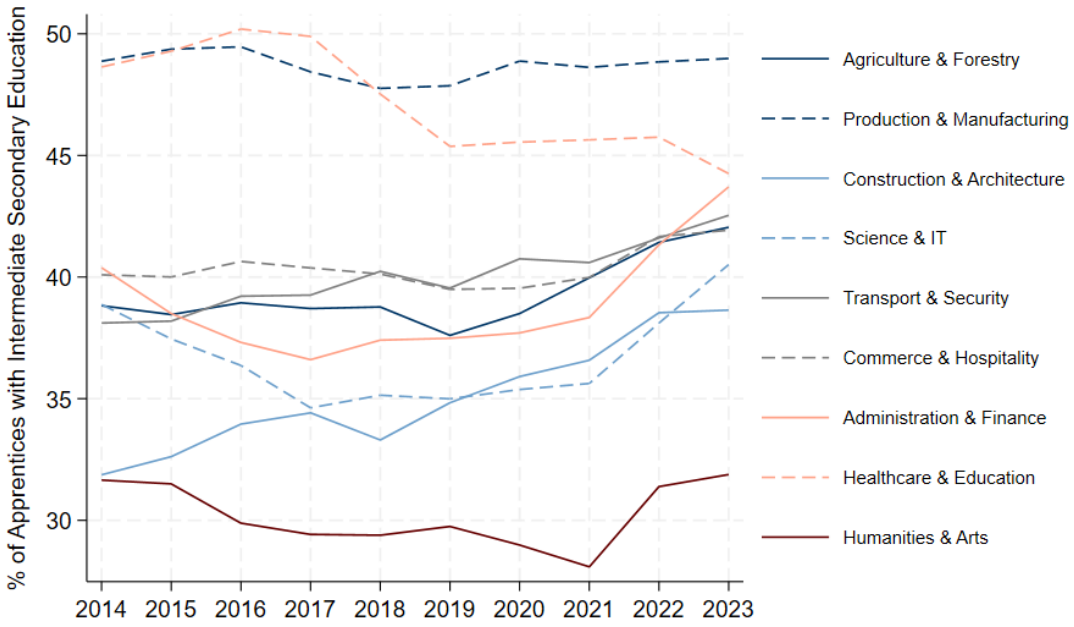

Figure A.9: Development of the share of newly commencing apprentices with a intermediate secondary degree per occupational area from 2013 to 2022.

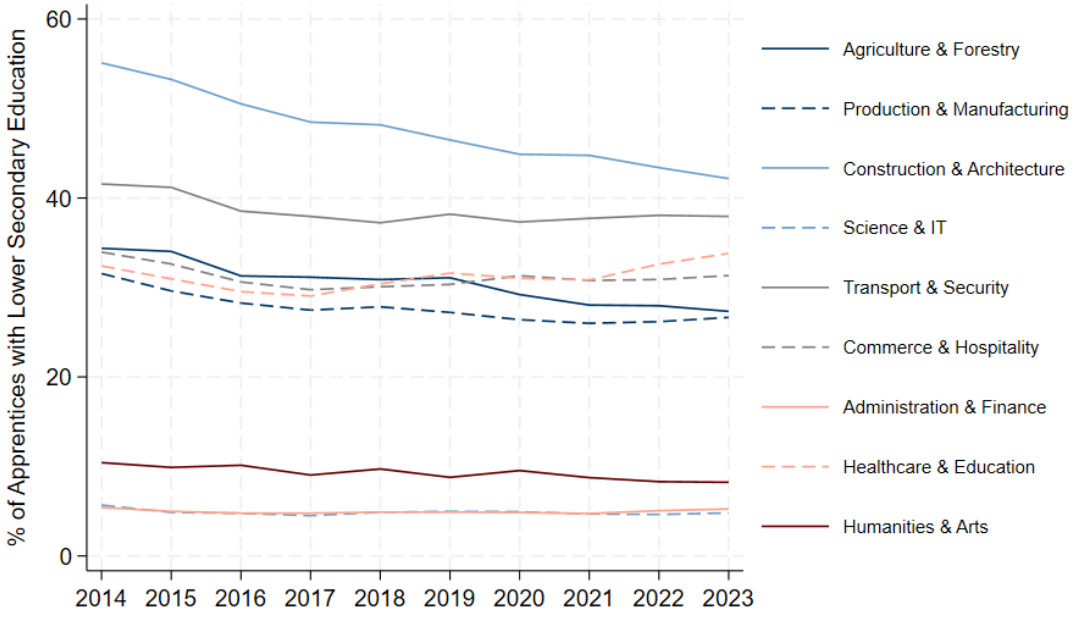

Figure A.10: Development of the share of newly commencing apprentices with a lower secondary degree per occupational area from 2013 to 2022.

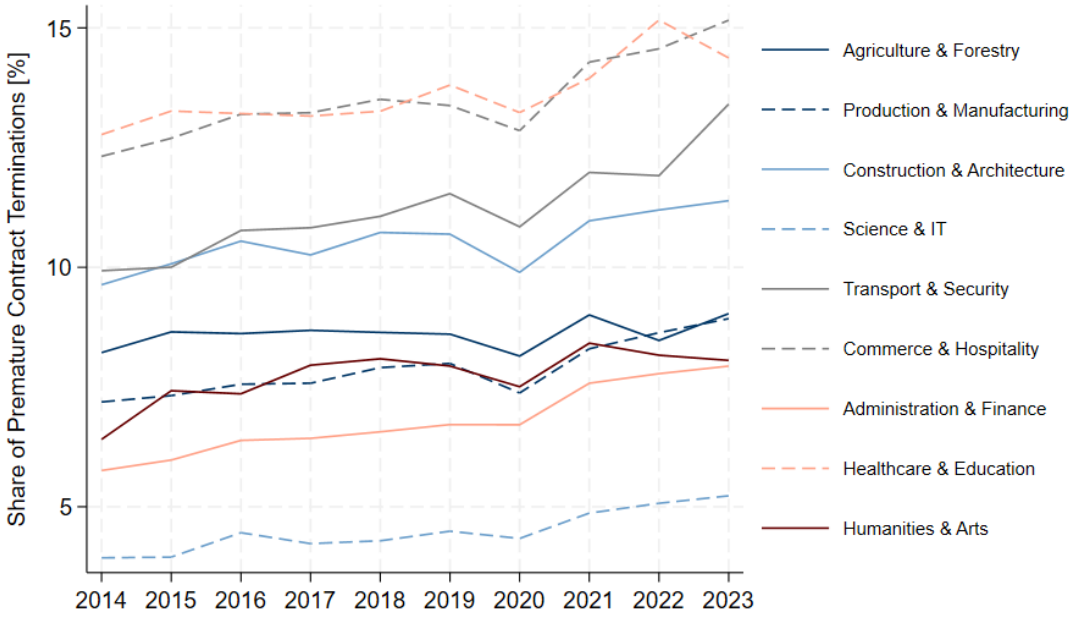

Figure A.11: Development of the share of prematurely terminated apprenticeship contracts per occupational area from 2013 to 2022.

B Findings

	Newly Commenced Apprenticeships (log)			% Terminated Apprenticeships		
	(1)	(2)	(3)	(1)	(2)	(3)
Unemployed Skilled Jobseekers per Vacancy	-.0018*	-.0017*	-.0010	.0077	.0063	-.1298***
(s.e.)	(.0008)	(.0008)	(.0009)	(.0108)	(.0109)	(.0379)
GDP/Capita		✓			✓	
Companies		✓			✓	
# School Leavers		✓			✓	
Year FE	✓	✓	✓	✓	✓	✓
N	13,846			13,846		

	% Higher Secondary Degree Appr.			% Intermed. Secondary Degree Appr.			% Lower Secondary Degree Appr.		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
Unemployed Skilled Jobseekers per Vacancy	.0219	.0206	.4468***	-.0144	-.0138	-.2004**	-.0103	-.0093	-.2584***
(s.e.)	(.0299)	(.0299)	(.0971)	(.0281)	(.0287)	(.0691)	(.0111)	(.0108)	(.0750)
GDP/Capita		✓			✓			✓	
Companies		✓			✓			✓	
# School Leavers		✓			✓			✓	
... with Higher Second. Degree [%]		✓			✓			✓	
... with Intermediate Second. Degree [%]		✓			✓			✓	
Year FE	✓	✓	✓	✓	✓	✓	✓	✓	✓
N	13,846			13,846			13,846		

Table B.1: Estimation results for the relationship between the ratio of unemployed skilled jobseekers per vacancy and various outcomes at the state × occupational group level where the estimates are obtained using (1) TWFE without controls, (2) TWFE with controls and (3) the robust approach developed by de Chaisemartin et al. [2024]. Clustered standard errors at the state × occupational group level are reported in parentheses. Significance levels: * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

	Newly Commenced Apprenticeships (log)			Apprenticeship Postings (log)			% Terminated Apprenticeships		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
BA Skilled Labor Shortage Indicator	.0002	-.0002	-.0008	-.0008	-.0007	.0024	.0025	.0030	-.0029
(s.e.)	(.0007)	(.0007)	(.0037)	(.0014)	(.0015)	(.0189)	.0161	(.0165)	(.1203)
GDP/Capita		✓			✓			✓	
Companies		✓			✓			✓	
# School Leavers		✓			✓			✓	
Year FE	✓	✓	✓	✓	✓	✓	✓	✓	✓
N		1,979			1,979			1,979	

	% Higher Secondary Degree Appr.			% Intermed. Secondary Degree Appr.			% Lower Secondary Degree Appr.		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
BA Skilled Labor Shortage Indicator	.0314	.0328	.0290	-.0883	-.0159	-.0176	-.0138	-.0161	-.0506
(s.e.)	(.0209)	(.0205)	(.0949)	(.0484)	(.0227)	(.0228)	(.0214)	(.0214)	(.1625)
GDP/Capita		✓			✓			✓	
Companies		✓			✓			✓	
# School Leavers		✓			✓			✓	
... with Higher Second. Degree [%]		✓			✓			✓	
... with Intermediate Second. Degree [%]		✓			✓			✓	
Year FE	✓	✓	✓	✓	✓	✓	✓	✓	✓
N		1,979			1,979			1,979	

Table B.2: Estimation results for the relationship between the BA skilled labor shortage indicator and various outcomes at the state × occupational group level where the estimates are obtained using (1) TWFE without controls, (2) TWFE with controls and (3) the robust approach developed by de Chaisemartin et al. [2024]. Clustered standard errors at the state × occupational group level are reported in parentheses. Significance levels: * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.