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The Effects of Expanding Higher Education on Wages and Establishments' Labor Demand

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Abstract

This study examines the impact of increased access to higher education on labor demand, wages, and labor market structure. I focus on the quasi-experimental increase in the number of universities and universities of applied sciences in Bavaria since the 1970s and establishment of such higher education institutes under the "Future of Bavaria Offensive" program in the 1990s.

I use administrative establishment-level data and find a positive but statistically insignificant effect on median wages resulting from expansion of higher education. While there is a negative but insignificant impact on wages of highly skilled workers, those without academic or vocational degree experience an increase in wages. I also find that training activities decline immediately after establishment of a new higher education institution. Further empirical analyses indicate that this decline is driven by changes in educational choices of school graduates rather than by labor demand of establishments.

Keywords: Expansion of higher education · Labor demand · Wages · Event-study design

JEL-Classification: I23 · J23 · J31 · C21

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1 Introduction

In industrialized countries, policymakers focus on fostering economic development in underdeveloped regions. Such targeted policies include subsidies or tax deductions to boost investment in capital and technology. Several studies have investigated the effects of such place-based policies on employment, wages, innovation, productivity, and establishment-level outcomes (summary available in Neumark and Simpson, 2015; von Ehrlich and Overman, 2020). A type of such policies are industrial cluster programs. These programs are often targeted at high technology sectors and intend to foster the collaboration between firms and universities (Falck et al., 2010, 2019; Martin et al., 2011).

Often, in such policies, a crucial role is played by the presence of a university that educates prospective workers, stimulates innovations, and attracts firms to regions. Usually, wages, employment, and qualification are higher in regions with universities. However, this relationship may suffer from endogeneity because the location of establishments and universities and education decisions of individuals are not random. When a university, especially that of applied sciences, is established in a region, firms experience a positive local supply shock that substantially increases the number of young and highly educated workers who are trained in STEM fields and are familiar with R&D-related tasks. I am interested in how the expansion of higher education affects the labor market. In particular, I examine how are wages, labor demand, and labor market structure affected.

Since the 1970s, the number of higher education institutes (universities, including those of applied sciences) and number of students have substantially increased in Germany.[1] This quasi-experimental increase has been examined by numerous studies to estimate the effect of higher education on health and cognitive abilities (Kamhöfer et al., 2019), fertility (Kamhöfer and Westphal, 2019), and labor market outcomes. Kamhöfer et al. (2019) estimated positive effects on wages and Westphal et al. (2022) confirmed this for women whose employment probability increases when education expands.

A few studies focus on firms' location decisions (Abramovsky et al., 2007; Abramovsky

[1] According to Kamhöfer and Westphal (2019), the number of students increased by a factor of 3 from the beginning of the 1960s until 1990.

and Simpson, 2011) and whether the location of higher education institutes affects innovation skills, R&D expenditures (Andersson et al., 2009; Toivanen and Väänänen, 2016; Pfister et al., 2021; Valero and Van Reenen, 2019), and economic development (Valero and Van Reenen, 2019). However, very few studies focus on hiring and paying strategy of firms and labor market structure in detail. This existing gap in literature is closely linked to my research question.

Examining the expansion of Swiss universities of applied sciences in the 1990s, Schultheiss et al. (2023) analyzed how job advertisements of firms change. High-skill content in advertisements increases. Advertisments addressing people without an academic degree but with vocational education also increases. This is accompanied by wage gains for workers with vocational education and an increase in the demand for those that can perform high-skill R&D-related tasks. This finding supports the theoretical model and individual-level evidence by Moretti (2004). Based on Rauch (1993), Moretti (2004) showed that college education in the United States positively affects wages of highly skilled workers but also wages of workers of lower education. Most importantly, he showed that the effect size is larger for workers with lower education than that for highly skilled workers.

Lehnert et al. (2020) considered the same institutional setting as Schultheiss et al. (2023). Using firm-level data, they estimated positive effects of expanding higher education on (absolute and relative) employment of R&D personnel and their wages.

My study makes several contributions to existing literature. First, I consider the quasi-experimental opening of higher education institutes in Bavaria. I study two waves of education expansion. After several universities (of applied sciences) were founded around 1977, the second wave of education expansion started around 1994, when a large number of new universities of applied sciences were established. Bavaria is an interesting case for studying the consequences of education expansion because several universities, including those of applied sciences, were established there in the 1970s, 1980s and 1990s. Therefore, Bavaria has experienced several waves of university establishments over various decades. That is, the Bavarian university landscape was not finalized at the beginning of the 1970s. In 1994, FBO I, the first period of the program "Future of Bavaria Offensive (FBO)" (*Offensive Zukunft*

Bayern), was initiated. This program included establishment of seven universities of applied sciences. Therefore, several of them were founded within a short period of time. Also interestingly, these universities of applied sciences were established in smaller cities that did not have any university before and that are located outside of metropolitan areas. Furthermore, those founded in the 1990s supplied education in STEM-related subjects. Therefore, education obtained at these institutes are linked to the need of the economy and labor market. Establishment of these institutes and the need for highly qualified workers was furthermore verbally demanded by employers' associations.

Second, very few studies examine the link between the supply of higher education and firms' hiring strategies. In addition, very few use establishment-level data to study the effects of establishing a new higher education institute on the labor market. Using establishment-level data to answer my research questions is more suitable than using individual data for considering spillover effects because I observe workers with different qualifications in the same establishment. Analyzing such spillover effects helps capture the entire image of effects from higher education and supports individual-level evidence provided by Moretti (2004).

Third, examining the opening of higher education institutes can also shed light on the current debate on labor shortage (not only in Germany). Policymakers and public often citicize that the trend to prefer studying to apprenticeship training during the last decades has caused labor shortage. However, educational decisions depend on several endogenous characteristics of the individuals and their parents. Moreover, present labor and industry structures and its needs are not comparable with those in the 1970s and 1990s. To delve into this issue deeper, I not only consider wages and labor demand of workers but also focus on the training activity of establishments, which has not been sufficiently examined previously. To address this research gap, I investigate the reason behind the reduced training activity by establishments in the 1990s. I also analyze whether this effect is driven by the fact that establishments substitute apprentices by highly skilled workers from new universities (of applied sciences) or whether establishments face problems with finding young people who are willing to start apprenticeship training (instead of studying).

Using the large administrative dataset from the Establishment History Panel (BHP) and applying the event-study technique by Sun and Abraham (2021) with staggered treatment timing, I find that establishment of a new higher education institute increases the hiring of highly skilled workers, particularly engineers and natural scientists. I find a positive but insignificant effect on median wage from expanding higher education. By focusing on the wage distribution, I confirm the theoretical model by Moretti (2004). While there is a negative but insignificant effect on wages of highly skilled workers, wages of workers without academic and vocational degree increase. Three years after establishing a new higher education institute, wages of the workers increased by 2 percent. Consistently, Moretti (2004) supposed that the risk of substitution after an increase of highly qualified labor supply is larger for highly skilled workers than for those with lower education.

I also find that training activity declines immediately after establishing a higher education institute. This effect is driven by a shift in educational decisions of school graduates and not by labor demand of establishments. Because I focus on higher education institutes of STEM-related subjects, these results apply to my baseline sample where I excluded from my empirical analysis the establishments with their main economic activity being in culture, education, social services, as well as economic or political parties or organizations, and general public or military administration.

Berlingieri et al. (2022) applied a similar approach as mine and focused on higher education institutes established during the 1980s and 1990s. Using regional data, they found effects on the regional share of high-skilled employment (mainly driven by the manufacturing sector) but no effects on average wages. However, they detected positive effects on wages of workers with non-academic background in high-tech manufacturing firms and those of young (aged 20–29 years) and older (45–60 years old) workers with non-academic background if only higher education institutes in STEM are considered. Moreover, their results hinted at large heterogeneity. In regions with dynamic labor markets, firm creation and skill level of the employed population is positively affected.

Berlingieri et al. (2022) used purely regional data and considered establishment of higher education institutes in entire Germany. My focus is different. I consider only the federal state of Bavaria and additionally examine the effects on training activity. I consider that educational decision of school graduates may change after the education expansion. Furthermore, I focus on wages by skill degree distinguishing among three groups: workers without vocational or academic education, workers with vocational education, and workers with academic education.

The remainder of this paper is organized as follows. In Section 2, I describe the institutional background and expansion of higher education institutes in detail. Section 3 illustrates theoretical expectations, data, and empirical strategy, with the empirical results being presented in Sections 4 and 5. Finally, Section 6 concludes the paper and derives policy implications.

2 Institutional Background

2.1 The Expansion of Higher Education in Germany and Bavaria

In Germany, graduates from secondary school (*Gymnasien*) are allowed to study at universities (of applied sciences). Since the beginning of the 1960s, Germany expanded the number of higher education institutes to fill in the substantial education gap compared to other European states after World War II and to address the shift in industrial labor demand. Kamhöfer et al. (2019) showed that from 1959 to 1990, the total number of colleges doubled and the number of students increased from 155,000 to over one million. In Bavaria, higher education started expanding at the beginning of the 1970s. The universities of Augsburg, Bayreuth, Ingolstadt, and Passau were established as universities with a general orientation.

Furthermore, in October 1968, the Federal Government and governments of the federal states implemented a new law that standardized the juridical founding of universities of applied sciences (*Fachhochschulen*, since 2000: *Hochschulen für angewandte Wissenschaften*). This law addressed the shift in industrial needs as well. Because of economic upturn in the 1950s and 1960s in Germany, the need for technical and highly skilled workers substantially increased. This led to a large number of universities of applied sciences being established in Germany. In Bavaria, universities of applied sciences were established in 12 new counties between 1970 and 1979. The regular duration of a diploma is three until four and a half years (depending on the certain exam regulation and syllabus) at a university of applied sciences.

2.2 The Program "Future of Bavaria Offensive"

Bavaria is the largest federal state of Germany in terms of area. In 2021, Bavaria accounts for about 20 percent of the German area and 16 percent of the population; to say, it is larger than Switzerland. It consists of 96 counties, or one-quarter of all German counties.[2] Bavaria also accounts for the second largest gross domestic product among of the German federal states.

At the beginning of the 1990s, the Bavarian government introduced the "Future of Bavaria Offensive" program (Offensive Zukunft Bayern, FBO). As a result, from 1994 to 1996, seven new universities of applied sciences were established in 12 counties. The FBO is of particular interest. The initial program of FBO (FBO I) included universities of applied sciences being established in smaller cities where no university existed before. Figure A.1 in Appendix shows how the establishment of universities (of applied sciences) evolved across time in Bavaria and how new higher education institutes were particularly established in marginal areas near the border to the Czech Republic and Austria and the border to other federal states (Baden-Wuerttemberg, Hesse, Saxony, and Thuringia).

The FBO is financed by privatizing state-owned companies. Alongside establishing new universities of applied sciences, FBO I also included establishment of apprenticeship and technology centers, promotion of non-university research and newly established companies (for more details, see Berger, 2002; Falck et al., 2010).[3] After FBO I, further programs followed. Since 1999, FBO III particularly promoted the high-tech sector. This follow-up program was studied by Falck et al. (2010) who analyzed the extent to which FBO III affected

[2] In the following, I use the term counties to describe counties (*Kreise*) and cities not associated with a county (*kreisfreie Städte*).

[3] Regarding my empirical strategy, the promotion of apprenticeship centers may affect my empirical results if the increase in apprenticeship centers were larger in the counties where a new university (of applied sciences) was established. By analyzing data from the Statistics of Vocational Schools of the Federal Statistical Office for 1992–2002, I find no correlation between the increase in vocational schools and treatment status. Therefore, counties in which a new university was established during my observation period do not display a significantly larger increase in vocational schools after the implementation of FBO I than counties where no university was established. The same is true for the increase in the number of students at vocational schools. Furthermore, the promotion of apprenticeship centers was less major in FBO I than the promotion of higher education. The public funds designated for the foundation of new higher education institutes was six times larger than the funds for the promotion of apprenticeship centers (Berger, 2002).

innovations and cooperation between research institutes and firms.

(Figure 1 about here)

Based on this institutional setting, I examine two waves of education expansion. The first wave was initiated in 1977, followed by the founding of the University of Passau and establishment of the universities of applied sciences in Kempten and Landshut. The second wave of education expansion started in 1994, for example, with new universities of applied sciences in Deggendorf and Hof. Although the expansion of higher education had already started before 1975—the first year of the BHP—my period under study is of significant meaning. I display the share of establishments located in a county with a university (of applied sciences) in Figure 1. Considering the entire state of Bavaria, this share jumps by about five percentage points around 1977 and by about seven percentage points around 1994. After the initiation of FBO I in 1994, the share of establishments located in a county in which a higher education institute is established jumps for the first time to above 50 percent. The two jumps are more pronounced when I exclude counties with higher education institutes established before 1975.[4]

Based on this institutional setting and demonstrated relevance of the two waves of education expansion, Section 3 formulates the research questions and hypotheses. Based on these hypotheses, Section 3 provides a more detailed look at the data used and empirical method applied.

3 Theory and Empirical Strategy

3.1 Theoretical Hypotheses

The establishment of universities (of applied sciences) focusing on STEM-related subjects increase the number of highly skilled workers available to the labor market after graduation. Therefore, I expect that establishments increase their demand for workers educated in one

[4]During the 1990s, the number of freshmen in the younger universities of applied sciences substantially increased (see Table A.1). Each higher education institute established in the context of FBO I had more than 100 freshman per year in the fifth year after establishment. The aggregate number of students at the higher education institutes established via the FBO I was more than 3,200 in the fifth year after its establishment. Therefore, the establishment of universities of applied sciences in those counties is immensely relevant.

of the new higher education institutes. Thus, I propose the first hypothesis:

Hypothesis H1: The establishment of new higher education institutes increases the demand for engineers and natural scientists by establishments.

I expect this effect to be more pronounced after some years because it takes some years until the first batch of graduates pass out from the institute. However, this effect may be visible right after establishing the higher education institute because students at universities of applied sciences often work at establishments during their study and employees of the UAS also often work at the UAS and the establishment simultaneously.

Schultheiss et al. (2023) examined how the demand for workers with different qualifications change because of the education expansion. They pointed out that a positive labor supply shock of highly skilled workers can have two opposing effects on labor demand with respect to different qualification degrees. If establishments assign redefined tasks to workers graduated from higher education institutes, vocationally trained workers are substituted and crowded out. On the contrary, establishments may employ the new graduates from universities (of applied sciences) as workers to complement existing vocationally trained workers and highly skilled workers graduated before the shock because the workers recently graduated bring new knowledge to establishments. This explanation becomes clear if I focus on universities of applied sciences. Schultheiss et al. (2023) pointed out that graduates of higher education institutes acquire practical scientific and technical knowledge. These graduates can, therefore, support both highly skilled workers who focus on scientific tasks and vocationally trained workers whose tasks are more of applied nature.

However, I focus on how establishments adjust their wages. Consistent with theoretical reflections by Schultheiss et al. (2023), general labor market theory suggests that the increase in highly skilled graduates may decrease wages of existing workers with academic background (see Moretti, 2004). On the contrary, Moretti (2004) supposed that the positive supply shock could also increase the wage of highly skilled workers through spillover effects. In this case, recently graduated highly skilled workers bring new knowledge and technology to establishments, which improves productivity of existing highly skilled workers who graduated. The substitution channel and spillover effect work in different directions considering highly qualified workers. If I follow Moretti (2004), I expect that the two effects work in the same direction regarding workers of lower education or the negative substitution effect is less strong than it is for highly skilled workers because the risk of substitution is more imperfect than for highly skilled workers. Schultheiss et al. (2023) found that the establishment of universities of applied sciences increases the wage of workers with a vocational degree because of increased employment of workers with vocational education. Based on these considerations, I propose the following two hypotheses considering the impact on wages:

Hypothesis H2: Establishing new higher education institutes increases the wages of low-qualified workers and vocationally trained workers.

Hypothesis H3: Due to the substitution effect, the positive effect of the education expansion on the wages of low-qualified and vocationally trained workers is larger than that for highly skilled workers.

I expect the effect of training activity of establishments to be similar as it is on labor demand for workers with vocational education. The education expansion may increase the demand for people with vocational education and the establishment may extend training activity (complementarity effect). However, due to the substitution effect, establishments may reduce the demand for vocationally trained workers and instead hire young people after or during their studying at a higher education institute. If the education expansion reduces the number of newly hired apprentices in establishments, the probability of hiring any new apprentice may be affected as my sample consists of a significant number of quite small establishments with only a few apprentices. The education expansion may have a negative effect because it also likely affects educational decisions of young people and makes it more likely that school graduates prefer studying to apprenticeship training (Spiess and Wrohlich, 2010; Siegler, 2012). For instance, Spiess and Wrohlich (2010) demonstrated that a new university close to hometown reduces transaction costs (through reduced rental and moving costs) and indirect costs emerging from emotional load, among other things. Thus, establishments may find it hard to staff all training slots because school graduates are more likely to enroll at a higher education institute and less likely to start apprenticeship training. If I find a negative effect on training activity from the education expansion, I have to disentangle whether this effect is driven by labor demand or by a shift in educational decisions of school graduates. I, therefore, propose the following hypotheses considering the impact on training activity:

Hypothesis H4: Establishing a new higher education institute decreases the number of newly hired apprentices and the probability of hiring any new apprentices.

Hypothesis H5: Education expansion on training activity may have a negative effect because establishments substitute apprentices by highly skilled workers from the new higher education institutes and/or more school graduates tend to prefer studying to apprenticeship training.

3.2 Data

I usde data from the weakly anonymous Establishment History Panel (BHP) (Ganzer et al., 2022, DOI: 10.5164/IAB.BHP7521.de.en.v1).[5] The BHP is based on the universe of the individual employment histories of the Institute for Employment Agency. In Germany, employers are required to submit annual notifications to the responsible social security agencies including information on the number of employees covered by social security and their individual information. Ganzer et al. (2022) described that these data are recorded by the health insurance companies and also collected by the Federal Employment Agency (BA) and integrated into the history file of the IAB. After the individual employment notifications undergo corrections and validation procedures by the Research Data Centre at the IAB, the employment spells are aggregated to the establishment level for establishments with at least one employee subject to social security or, since 1999, one marginal part-time employee as of 30 June of a

[5] Data access was provided via on-site use at the Research Data Centre (FDZ) of the German Federal Employment Agency (BA) at the Institute for Employment Research (IAB) and via remote data access.

given year (for more details on these procedures, see Ganzer et al., 2022, pp. 15-26). The Research Data Centre then draws a 50 percent simple random sample from this core dataset, which I use for analysis.

The BHP has detailed information on outcomes related to my research questions. Besides the establishment composition regarding qualification and kind of employment, it provides information on earnings of full-time employees, earning distribution, and earnings with respect to qualification. Importantly, the BHP excludes apprentices when the average wage per establishment is calculated. As per the BHP, low-qualified workers have not completed apprenticeship training or studying. Middle qualified workers have successfully finished apprenticeship training and highly qualified workers have graduated from a higher education institute.

Furthermore, the dataset separately reports the number of engineers and natural scientists employed in the establishments, which I use as a proxy for R&D activities. Because I focus on how the education expansion affects training activity, it is useful that BHP provides information on the number of newly hired apprentices.

To identify the treatment, which is the founding of a new university (of applied sciences), further datasets are required. I used data from the Higher Education Compass (*Hochschulkompass*, offered by the German Rectors' Conference) to identify the year of foundation of the universities (of applied sciences). I verify the information obtained by official statistics of the German Federal Statistical Office and add information on the number of freshmen per university (of applied sciences) and semester.[6]

I am interested in the effects of founding a general university or a university of applied sciences. Hence, I excluded higher education institutes that only offer public administration, theology, education, and social affairs. I only considered establishment of universities of applied sciences in at least one STEM-related subject (science, technology, engineering, and mathematics). I included pedagogical universities as long as those were later developed to universities with a general orientation or were incorporated into facilities with a general

[6]In 1975, there was a break in the kind of publication how the Federal Statistical Office published statistics on universities and students. Until the winter term 1974/75, the number of freshman was published in "Hochschulbesuch (kleine Hochschulstatistik)" (Fachserie A Reihe 10). Since winter 1975/76, the numbers were provided in a new publication series called "Studenten an Hochschulen" (Fachserie 11 Reihe 4.1).

orientation. Furthermore, I faced several challenges during data preparation. I only assigned a treatment to a county if there were a foundation and no higher education institute existed there before.[7] From the empirical analysis (baseline sample), I excluded establishments whose main economic activity was in culture, education, social services, as well as economic or political parties or organizations, and general public or military administration.

I used the observation period from 1975 to 2002. Thus, the introduction of tuition fees in 2006 does not affect my estimates. Furthermore, since 1999, the BHP includes establishments with at least one marginal part-time employee. This increased sample size and sample composition in a significant way (see Section 5.1 for robustness check).

3.3 Empirical Issues and Identification Strategy

This study examines the extent to which the presence of higher education institutes affects wages, training activity, and labor demand for engineers and natural scientists. Usually, wages (and employment) are higher in regions where universities (of applied sciences) are located than in regions without such institutes. However, this relationship may suffer from endogeneity because the location of higher education institutes is correlated with other factors that lead to larger wages in those regions, e. g., the presence of large and successful enterprises. In addition, the location of establishments is also not random. Establishments that rely on labor demand for highly skilled workers with academic qualification are more likely to settle in regions where higher education institutes are located.

This endogeneity is illustrated in Table 1, where I provide descriptive statistics on outcomes and further establishment-level characteristics for years just before the two waves of education expansion. For the first wave of education expansion initiated in 1977, the pre-treatment years are 1975 and 1976. For studying the effects of FBO I, I use the period from 1990 until 1993 as the pre-treatment years because the program started in 1994. Descriptive statistics are displayed for three groups: the treatment group where a higher education in-

[7] For instance, the Munich University of Applied Sciences was established in 1971; however, two large universities already existed in Munich. Therefore, Munich received a treatment before 1970. A similar case is Ansbach, where a new university of applied sciences was established in 1996 following FBO I. However, the university of applied sciences in Weihenstephan and the Evangelical University of Applied Sciences, Neuendettelsau, already existed there.

stitute was established after 1975, the control group where no higher education institute had been ever established, and counties where a higher education institute had been established before 1975. This latter group is excluded from the econometric analysis because in those counties, a higher education institute was already present in the first year of my observation period. By construction, the estimator presented in the next section excludes units treated in the first period. This makes the treatment group and control group more homogeneous and more comparable. To what extent, this also reduces endogeneity in my estimations is explained in the following. A natural drawback of excluding those counties is that the estimates are not representative for entire Bavaria anymore.

Table 1 illustrates that median wage of all workers and median wage for all kind of qualifications are higher in counties where a higher education institute had already been established before 1975. In 1975 and 1976, median wage in counties with a higher education institute established before 1975 was €14.0, whereas median wage was €13.1 in counties where a higher education institute was established after 1975 and €12.9 where no higher education institute was established (Panel A of Table 1). Establishments located in those counties also differ regarding other factors, for example, in composition with respect to gender and qualification. The underlined differences are also present in Panel B of Table 1 when descriptive statistics are displayed for the years 1990–1993 before the start of FBO I.

(Table 1 about here)

Regarding training activity, the share of establishments with at least one newly hired apprentice is the lowest in counties having a higher education institute before 1975 (27.0 percent in Panel A); while 34.9 percent and 33.6 percent of establishments in the treatment and control group, respectively, hired new apprentices. However, the average number of new apprentices is comparable among the three groups. This may indicate that large companies more often choose big cities with larger population density and those cities are often located in counties that have a higher education institute established before 1975. This presumption can be confirmed by looking at establishment size, which is the smallest in counties where no higher education institute was founded before or during the observation period.

A quasi-experimental variation in the supply of higher education is essential to estimate a causal effect on the labor market. When a university, particularly a university of applied sciences, is established in a region, establishments experience a positive local supply shock that substantially increases the number of young and highly educated workers trained in STEM fields and familiar with R&D-related tasks. Considering such an exogenous shock is, therefore, a senseful strategy to reduce endogeneity in the relationship between the supply of higher education and wages. To overcome this bias, I consider two periods in which several new higher education institutes were established.

Based on Berger (2002), Kamhöfer et al. (2019), and Westphal et al. (2022), the decision where a new higher education institute was established followed a quasi-random path in my setting, even though the decision was not made by lottery. Several ministries of the Bavarian government decided where a new university (of applied sciences) is established. According to Bunde et al. (2022), in the 1970s, cities where no higher education institute existed before were preferred to avoid overcrowding typical university cities. FBO I also promoted founding of new higher education institutes in smaller cities that did not have any university before and outside of metropolitan areas (Berger, 2002). As Kamhöfer et al. (2019) and Westphal et al. (2022) highlighted, a new higher education institute has larger effects where the demand for higher education is larger Due to education experts, this was more likely in big cities at that time where a university has already been established. This shows that the decision in which county a new higher education institute is founded does not implicitly follow economic factors.

The education expansion also aimed to meet the industry's increasing labor demand for highly skilled workers. Thus, it is a methodological advantage that the issue of large labor demand for highly skilled workers was homogeneously spread in Germany and Bavaria (Westphal et al., 2022). Even if there were a superior goal behind establishing new higher education institutes, the final decision of choosing the county was highly unclear and complex at the beginning of the political and administrative process. The feasibility of founding a new higher education institute depends on various factors such as the number of school graduates with university entrance permit; however, it also depends on factors such as the availability of buildings, infrastructure, and lecturers. However, these local factors were not evaluated at the beginning by a central institution. Instead, the lack of physical space sometimes only became apparent during the process and impeded the entire process. Moreover, as a new higher education institute in a county is a prestigious project for local political representatives, different regional interests tried to influence the decision in their favor. As a result, the decision was affected by a large number of random political factors. This argument is supported by statements from representatives of counties, unions, and industry after 1994, who criticize that the promotion of higher education and technology centers did not follow economic factors and new institutions did not emerge where they were mostly needed (Berger, 2002, pp. 34-36). These political-economic factors demonstrate the complex and decentralized character of the decision of establishing a new institute.

Table A.2 in Appendix examines whether counties where a new higher education institute was established in the context of FBO I and counties where no higher education institute was established differ from each other.[8] In the table, the binary treatment status is regressed on county characteristics such as population (density), age structure, school graduates, pupils at vocational schools, and further economic determinants. In specifications 3 and 4, I add county composition with respect to the degree of qualification and economic sector as explaining variables. Although the population size of a county is a significant explaining factor of the treatment status in the first plain specification (without any other covariate than population size), this significance vanishes after controlling for further county characteristics.[9] Taken together, the regressions demonstrate that treatment and control counties do not differ much in terms of structural, economic, and demographic factors.

Table 1 shows the reduced endogeneity by focusing on counties with no higher education institute in 1975. Establishments located in counties where no higher education institute had been established until 1975 (treatment and control group) are much more similar to each other and only differ to some modest level. For instance, median wage of all workers and median wage with respect to the degree of qualification are comparable between those two groups. For instance, median wage for all workers only differ by €0.2 in 1975 and 1976 and by

[8]Due to data availability restrictions, this analysis was restricted to the second wave of education expansion under study.

[9]The same applies if I replace the continuous variable of population and squared population by a categorical variable with five categories.

€0.4 from 1990 to 1993. The same applies to training activity. However, here some differences appear, even though differences to establishments located in counties with a higher education institute established before 1975 are much larger. The share of establishments hiring at least one new apprentice is about 34.9 percent in the treatment group and about 33.6 percent in the control group (Panel A). However, the average number of new apprentices is comparable between the two groups.

An issue for the identification strategy presented may be that school graduates can move from their hometown to where the higher education institute is located. Such moving patterns may bias my estimates. However, a new higher education institute nearby the parental home makes moving less necessary and enables more students to study because staying at hometown makes studying less expensive (see Section 3.1). Several studies show that joining a higher education institute becomes more likely when it is located near the hometown (e.g., Spiess and Wrohlich, 2010; Siegler, 2012).

Based on the identification strategy, I present the estimation method in Section 3.4. I also explain further empirical issues related to this method and underlying assumptions.

3.4 Empirical Method

To estimate the effects of establishing a new higher education institute, I set up an event-study model in equation 1. My main outcomes y_{ijt} are median wage, training activity, and labor demand for engineers and natural scientists (ENS) of establishment i located in county j in year t. I use the fixed-effects specification where the binary variables $Treat^{\tau}_{jt}$ display the treatment status and τ indicates time relative to the founding of a higher education institute. For instance, $Treat^{0}_{jt}$ is a binary variable that switches to one for the treatment group in the year of the foundation. The parameters of interest β_τ display the effect on the outcome in pre- and post-reform periods from $\underline{\tau}$ until $\bar{\tau}$.

$$y_{ijt} = \alpha_i + \sum_{\tau=\underline{\tau}}^{\bar{\tau}} \beta_\tau Treat^{\tau}_{jt} + EstSize_{it}\gamma + \theta_j + \lambda_t + \delta_s + \varepsilon_{ijt} \quad (1)$$

Equation 1 includes year fixed-effects λ_t to control for general time trends in wages, training activity, and labor demand of engineers and natural scientists affecting all establishments in the same way and county-fixed effects θ_j to control for time-invariant regional differences in the outcomes. As the treatment is defined via geography, I cluster standard errors at the county level. Consistent with existing studies (Lehnert et al., 2020; Schultheiss et al., 2023), I control for fixed effects for economic sectors δ_s. Wages, training activity, and labor demand of engineers and natural scientists (and the composition of the staff in terms of qualification) depend largely on the economic sector to which the establishment belongs. Therefore, establishments of different economic sectors may react differently to newly established higher education institutes. Section 5.2 provides empirical evidence for this presumption where the effect of a newly established higher education institutes on the outcomes is analyzed with respect to the economic sector.

Because staff size of an establishment affects wages and labor demand of the establishment, equation 1 controls for the size of the establishment indicated by the number of workers $EstSize_{it}$. Although the share of female and foreign workers and establishment composition by qualification are also important determinants of wages or labor demand, I exclude them from the set of control variables in equation 1. This is because the establishment composition by gender and citizenship (or migration background) is largely affected by the expansion of higher education. Although this also applies to the size of the establishment because a positive increase of highly skilled workers entering the labor markets can lead to an increase in the labor demand, the endogeneity is likely larger in the staff composition by gender and citizenship than in the establishment size. This may be because the labor market performance of females and migrants changed fundamentally during my observation period because of political reforms in the field of family and migration policy.[10] To ensure that the omitting establishment composition by gender, citizenship, and other characteristics do not bias my empirical results, I present a specification in Panel B of Table 2 where I include the informa-

[10] While female access to education and labor market performance was eased through several reforms including gender equality rights in the labor market and day-care of children, migrants access to German citizenship and language training was fundamentally re-organized. Furthermore, composition of migrants arriving in Germany substantially changed during the 1990s in the context of the war in Yugoslavia and the end of the communistic German Democratic Republic.

tion from the establishment's first appearance in the panel.

I used the interaction-weighted estimator by Sun and Abraham (2021) to estimate equation 1. The issues of staggered timing of treatment across counties and negative weights in some treatment estimates due to effect heterogeneity can be handled by several approaches. However, the approach by Sun and Abraham (2021) offers several advantages in my specific setting. First, like most other related methods, the estimator allows estimating the dynamic path of treatment effects and considers whether effects from other periods contaminate the average treatment effect. Considering the dynamic evolution of the treatment effect is important in my setting. While there may be a direct effect on establishments' training activity in the first year of the universities' establishment, I expect effects on wages to emerge only after the first graduates enter the labor market. Second, Braghieri et al. (2022) demonstrated that the estimator by Sun and Abraham (2021) is less demanding and more flexible regarding the number of years used as reference periods compared to the estimator by Borusyak et al. (2024). This feature is particularly useful in Section 5.3, where I use a smaller dataset restricted to years from 1993 to 1997 to examine why training activity declines after establishing a new higher education institute. According to simulations of Rüttenauer and Aksoy (2024), the requirement to only use one year as the reference period makes the estimator by Sun and Abraham (2021) less likely to suffer from violations of parallel trends.

Third, the alternative estimator by Callaway and Sant'Anna (2021) is often applied because of the possibility of including not-yet treated units in the control group. Often this extended control group is more comparable to the treatment group. As the size of the control group increases, the estimator may gain efficiency. However, in my case, the group of never-treated establishment is large. Marcus and Sant'Anna (2021) explained that the gain in efficiency is low in such cases. While including not-yet treated establishments to the control group, requirements to the assumption on parallel trends are weaker. When using the estimator by Callaway and Sant'Anna (2021), Marcus and Sant'Anna (2021) showed that with such a control group parallel trends are only required to assume after the first establishment is treated. Therefore, parallel trends for the earliest treated establishments are not required to assume. However, because the first establishments are treated very early in year 1977, two years after the beginning of my observation period, this advantage is only of minor relevance in my setting. To illustrate these arguments, I come back to this issue in Section 4.2 when presenting my empirical results.

Furthermore, Berlingieri et al. (2022), who researched a similar research question for Germany, also used the estimator by Sun and Abraham (2021). This is a minor, albeit useful, reason for using this method, as it improves comparability of the empirical results.

This empirical method makes five general assumptions. Having panel data and some staggered treatment design, in which the treatment is irreversible and permanently in periods after the treatment, is a prerequisite. I assume that for each treated establishment with some characteristics, there are at least one further untreated establishment with the same characteristics and no establishment is treated in the first period (overlap condition). A clean identification of β_τ also assumes that the treatment has not been anticipated. By considering a staggered treatment design, the examination of this assumption is facilitated.

Finally, I assume parallel trends between the treatment and control group: the outcome under study would have evolved similarly if the treatment did not take place. Sun and Abraham (2021) imposed a strict version of this assumption because they assumed parallel trends for every group and between every pair of sequential time periods. An advantage of this version is that the existence of parallel trends is testable and these tests provide evidence to what extent this assumption is valid (Marcus and Sant'Anna, 2021).

To further investigate the validity of assuming no anticipation and parallel trends, Figure 2 presents a descriptive consideration of the relevant outcome variables before and after the education expansions were initiated. The two periods of education expansion under study hold significant meaning. The share of establishments located in a county in which a higher education institute is established significantly jumped in 1977 and 1994 (Figure 1). To analyze whether a corresponding jump is visible in wages and training activity, I distinguish three groups in Figure 2: the treatment group where a higher education institute was established after 1975, the control group where no higher education institute had been ever established and counties where a higher education institute had been established before 1975.

(Figure 2 about here)

In Panels a-d of Figure 2, there is a clear positive development of median wage since 1975 in general and for each degree of qualification for all three groups. In addition, median wage in counties where a higher education institute had been established before 1975 is above-average; so, the gap between this group and the counties where a higher education institute was established after 1975 and counties where no higher education institute was ever established increases. Because the majority of higher education institutes that emerged before 1975 was established around 1970, the foundation of universities (of applied sciences) may be the reason for this positive development. Regarding the treatment and control group, where a new higher education institute had not been established before 1975, the trend in median wage is parallel for the years 1975 and 1976 and before 1994 when FBO I was initiated. The same applies to the median wage by qualification degree. For instance, average growth of median wage of low-qualified workers is respectively 7.4 percent in the treatment and control group from 1985 to 1993, which I use as the pre-treatment observation period when examining FBO I. Again, no diverging trend is visible between the treatment and control group before the education expansion started. Therefore, there is no hint at a violation of the assumption of no anticipation—at least descriptively. If establishments had anticipated the imminent founding of a new higher education institute in a county and moved there, this would also pose a problem for the assumption of no anticipation. By examining the first appearance of establishments and establishments with a changed residence in my establishment-level panel data, I do not see any significant correlations between newly emerged establishments or establishments moving to another county in the last years before the education expansion started and their treatment status.

To provide further analyses for the assumption of no anticipation and for the assumption of parallel trends, I provide estimates of pre-treatment effects in Section 4. These estimates and subsequent tests examine the violation of the assumption of no anticipation and parallel trends (Marcus and Sant'Anna, 2021).

In 1994 and the subsequent years, median wage of all workers developed rather parallel between the treatment and control group. For the median wage of low-qualified persons, it is different. After the implementation of FBO I, the growth of median wage of the treatment group exceeded the wage growth in the control group after 1994. Consequently, median wage of low-qualified workers in the treatment group exceeded the wage of those in the control group. Although this appears as a small difference, the median wage displayed in Figure 2 is based on about overall 75,000 observations per year for the treatment and control group, which includes a substantial degree of heterogeneity tackled by the estimations in the next section and a closer look at heterogeneous effects in Section 5.2. Nevertheless, Figure 2 clarifies that after FBO I was initiated, treated establishments experienced a larger growth of the median wage of low-qualified workers. Such a pattern cannot be seen for the wages of medium and highly qualified workers. Therefore, I expect that the estimates in the next section show positive effects on wages of low-qualified workers and these positive effects are more pronounced than those for medium and highly qualified workers.

Figure 2e and f show that the share of establishments hiring at least one new apprentice is slightly larger in the treatment group than in the control group in the years before FBO I was initiated. However, this difference of about 1.5 percentage points is almost stable until 1994. The trend between the two groups is also comparable in Panel f that shows the number of newly hired apprentices. The intensive margin of training activity is very comparable between the two groups until 1994. After the implementation of FBO I, the gap in the share of establishments hiring at least one new apprentice between the treatment and control group decreases (Panel e). In 1994, this share is about the same in the two groups, while before 1994, the share was steadily larger in the treatment group. A similar pattern can be seen at the intensive margin. The number of newly hired apprentices declines in the treatment group and even falls below the training activity of the control group after 1994, while this number was about the same before 1994. Both effects seems to be larger in the longer run.

There is one limitation of the empirical method I applied. Using of a binary treatment contains the risk of biasness because I do not consider the size of a new university (of applied sciences) and differences in the number of students and freshmen in the treated counties. Moreover, by excluding counties with a newly founded higher education institute before 1975 (always-treated units), I do not consider how the number of students and freshmen evolved there.[11] By construction, the estimator by Sun and Abraham (2021) excludes units treated in the first period. An alternative approach would be to extend the estimator and use a continuous treatment variable. For instance, Callaway et al. (2024) and de Chaisemartin et al. (2024) extended their estmator to a continuous treatment. However, the scientific debate on the issues related to this extension continues. Using such an approach has drawbacks and limitations to consider. For instance, de Chaisemartin and D'Haultfœuille (2022) explain that the issue of negative weighting might increase with non-binary treatment. Furthermore, in my setting, a large share of my sample was not treated (and has therefore zero students), which produces further bias when using a continuous variable. Therefore, I decided not to extend my estimations to the case of a continuous variable.

4 Baseline Results

4.1 Employment of Engineers and Natural Scientists

Before I consider the effects of education expansion on wages and training activity, first, I consider how establishing a new higher education institute affects the labor demand for engineers and natural scientists (ENS). Figure 3 presents results of estimating equation 1 where I control for fixed effects for years, economic sectors, counties, and establishment size. I show results for the full sample including all economic sectors and the baseline sample where I exclude establishments associated with culture, education, social services, economic or political parties or organizations, and general public or military administration.

Panel A of Figure 3 illustrates that after establishing a higher education institute in period 0, the share of engineers and natural scientists relative to all employees significantly increases by 0.07 percentage points and the share of establishments employing engineers and natural scientists increases by 0.2 percentage points, which amounts to an effect of about 14.3 percent compared to the pre-treatment level in the treatment and control group. In the subsequent years, this effect continues to increase. In the baseline sample, the effect sizes

[11] In the 1990s, the number of freshmen decreased in counties that had already a higher education institute before 1975 (see Table A.1 in Appendix). As a result, the aggregate number of students and freshmen seems to stagnate in Bavaria in the 1990s. However after establishing new higher education institutes, the geographic distribution of students became more uniform across Bavaria.

decrease a bit. Moreover, confidence intervals are more precise. This shows that the effects are not exclusively driven by employment of engineers and natural scientists at educational institutes. Interestingly, the employment of engineers and natural scientists was not affected before the opening of the higher education institute. The FBO I period in Panel B shows that effect sizes stay very similarly. Therefore, I summarize that Hypothesis H1 is undoubtedly confirmed, whereas the education expansion increased the establishments' need for engineers and natural scientists. Moreover, no pre-treatment coefficient in Figure 3 significantly differs from zero. Using the approach by Sun and Abraham (2021) and explanations by Marcus and Sant'Anna (2021), the estimates and subsequent tests that do not hint at something different are valid to examine the existence of anticipation effects and diverging pre-treatment trends.

(Figure 3 about here)

At first glance, it may be surprising that the hiring of engineers and natural scientists increases immediately in the same year in which the higher education institute is founded. This finding is presumably driven by universities of applied sciences where employees cooperate with firms. Such a cooperation often entails a (part-time) employment contract with the firm.

While establishments did increase the hiring of engineers and natural scientists after a higher education institute was established in their county, it is possible that low-skilled and medium-skilled workers were substituted. However, in empirical analyses excluded from Figure 3, I do not see any significant effect on the absolute number and the relative share of low-skilled and medium-skilled workers after the establishment of a higher education institute. However, the share of highly skilled workers increases by 0.2 percentage points until the second year after the establishment of the higher education institutes or 11.7 percent (compared to the pre-treatment level). In addition, the absolute amount of highly skilled workers is significantly affected. This is not surprising as engineers and natural scientists are among highly skilled workers.

4.2 Wages

When considering the effects on wages (and training activity), I focus on my baseline sample where I exclude economic and political parties or organizations, general public or military administration and establishments dealing with culture, education, and social services. Figures 4 and 5, show how the education expansion affected wages. In Figure 4, first, I consider the whole observation period from 1975 until 2002. After the foundation of a higher education institute in period 0, the coefficients in Panel a describing the effect on the median wage turn positive. However, the effects stay insignificant except in period 5 and 8 where the coefficient is weakly significant (at a significance level of 10 percent). This is consistent with labor market theory that wage effects are only visible after some years after first graduates enter the labor market. However, evidence for long-term wage effects are weak.

(Figure 4 about here)

To further test theory by Moretti (2004) and Schultheiss et al. (2023), I consider median wage with respect to qualification groups. Panel b illustrates a significant positive effect from education expansion on median wage of low-skilled workers. At period 3, the first graduates of the new higher education institutes enter the labor market. Consistently, the coefficient in period 3 becomes significant, illustrating a positive effect of 1.7 percent on the median wage. Afterwards, the effect size slightly increases to 2.0 percent in period 5. For the other two qualification groups, there are no positive effects. Although the coefficients regarding the median wage of medium-qualified workers turn positive after period 0, the effects are insignificant. In Panel d of Figure 4, education expansion shows a negative effect on median wages of highly skilled workers in period 4, 6, and 8; however, those effects are weakly significant. Therefore, I cannot confirm that wages of highly skilled workers are reduced because of the education expansion. Nevertheless, these results confirm labor market theory by Moretti (2004), who states that the negative effect on wage outperforms the positive effect, when considering highly skilled workers. In addition, he expected positive wage effects to be most likely for lower skilled workers. This is confirmed by my estimates.

When considering the wage of the three skill groups, the sample size is reduced because not all establishments employ all three groups. Workers can be distinguished by skill or productivity without reducing the sample size by considering quartiles of the wage distribution. This confirms the results of Figure 5. I find a significant effect on the wage at the 25th percentile of 1.1 percent in period 5 and no significant effect on the wage at the 75th percentile.

(Figure 5 about here)

The results are confirmed for the FBO I period outlined in Figure 5. While the positive effects on the median wage of low-skilled workers exceed 2.5 percent in the long term, the median wage of highly skilled workers is not significantly affected anymore. Moreover, the effect on wages of low-skilled workers increases in size until period 7. However, the change in effect size after period 5 is marginal. Therefore, I presume that FBO III, which was initiated in 1999, has only small effect.

Figures 4 and 5 already control for fixed effects for years, economic sectors, counties, and establishment size. Therefore, it can be assumed that coefficients and standard errors stay almost same after stepwise adding those controls. Considering the median wage of low-qualified workers in period 3 (oberservation period from 1975 to 2002), the coefficient increases only slightly from 0.01667 to 0.01672 after controlling for economic sector and to 0.01659 after controlling for establishment size. That is, Hypotheses H2 and H3 are confirmed: a significant effect of the education expansion on wages of low-skilled workers is found and this effect is larger than the analogue effect on wages of highly skilled workers. However, on the contrary to the initial statement of H2, a positive wage effect for vocationally trained workers was not found.

The empirical results regarding wages are also rather robust when applying an alternative estimator. Although the estimator by Sun and Abraham (2021) provides several advantages in my specific setting, only never-treated establishments can be included in the control group and not-yet treated establishments have to be excluded from the control group. Therefore, I applied the estimator by Callaway and Sant'Anna (2021) that also allows to use the latter group to serve as the control group. Considering the observation period from 1985 to 2002 (FBO I period) and applying this estimator and using never-treated establishments as the control group, the estimate for low-skilled workers in period 3 of 2.30 percent is comparable to my baseline estimate of 2.02 percent when using the estimator by Sun and Abraham (2021). Including not-yet treated establishments into the control group changes the estimate only minor to 2.36 percent. The same applies to the other periods and outcomes under study. Therefore, applying the estimator by Callaway and Sant'Anna (2021) confirms that including not-yet treated establishments into the control group does not noteworthy change the estimates.

4.3 Training Activity

Empirical effects on wages appear only after graduates of higher education institutes enter the labor market. When considering the effect of education expansion on training activity of establishments, it is different. Usually, young people begin an apprenticeship training or studying right after school graduation. If they choose an apprenticeship training instead of entering a university (of applied sciences) because of the education expansion, this effect should be seen right after the new higher education institute was established. On the contrary, if establishments reduce the hiring of apprentices and substitute apprentices with graduates of the new higher education institutes, this effect is expected only after the first graduates enter the labor market. Therefore, if there is a negative effect of the education expansion of training activity, it can be explained by a shift in educational decision made by school graduates or by reduced demand of establishments for apprentices. However, if this effect reveals immediately after the foundation of the new higher education institute, it implies that the effect is driven by a shift in educational decision of young people.

(Figure 6 about here)

Panel A of Figure 6 illustrates that the probability of hiring new apprentices significantly decreases (-0.8 percentage points) two years and the number of new apprentices (-0.04 apprentices) one year after establishing the higher education institute. If I consider the FBO I period, the negative effects emerge rightly after establishing the higher education institute. The probability of hiring new apprentices is reduced by 1.2 percentage points in period 1 and the number of new apprentices by 0.05 apprentices in period 0. These effects increase in the subsequent years up to 2.1 percentage points regarding the probability to hire any new apprentices and 0.08 apprentices at the intensive margin. If I compare the effect at the extensive margin with the pre-treatment level of training activity of 30.6 percent in the treatment group (see Table 1), the effect amounts to a decrease in the share of establishments hiring any apprentices of about 6.9 percent. These results confirm Hypothesis H4, according to which I expected a negative effect on the number of newly hired apprentices and on the probability to hire at least one new apprentice.

In the 1990s, when FBO I was initiated, the task to recruit young people for an apprenticeship training was more difficult than in the 1970s and 1980s. A stronger decline in training activity in Panel B of Figure 6 than in Panel A may imply that the negative effects are mostly driven by a shift in educational decisions by school graduates.

5 Further Empirical Analyses

5.1 Sensitivity Analyses

To test the robustness of my results, I performed several sensitivity analyses. To reduce the complexity of my illustration, I focus on the FBO I period in the following. First, I tackle the issue that since 1999, the BHP considers marginally employed workers as an additional form of employment and therefore establishments are included even if they only employ such workers (Ganzer et al., 2022). Marginally employed workers differ in salary and education compared to other workers. This change also affects the composition of establishment, for example, with respect to education. In Panel A of Table 2, I exclude establishments with a very large share of marginally employed workers (larger than 70 percent).[12] The relevant effects on median wages of workers by qualification and training activity remain robust while effect size changes slightly.

(Table 2 about here)

Second, the establishment's composition regarding gender, nationality, kind of employment, and qualification may also affect wages and training activity. However, these variables may also be affected by the education expansion. I, therefore, excluded these variables from my specification. However, in Panel B, I add the share of female and foreign workers and the kind of employment (share of regular workers and share of full-time or part-time workers). To reduce endogeneity, I include these only from the establishment's first appearance in the

[12] The results remain same if I extend this border to 80 or 90 percent.

panel. The results stay fairly robust. For instance, the effect on median wages of low-skilled workers in period 3 of 2.0 percent stays the same. The same applies to results for training activity. In addition, this does not change if I add initial composition by qualification (results not explicitly presented in this paper).

Third, I cluster standard errors at the establishment level in Panel C. While effects on wages become slightly stronger, the negative effects on training activity become slightly weaker but stay of clear significance.

Fourth, in Panel D, I tackle the issue of having county-level information on the location of establishments and thus exact (geographical or temporal) distance between the establishment and the higher education institute is unknown. In Bavaria, big cities often form one county (*kreisfreie Stadt*) but are surrounded by associated counties. For instance, Hof, where a university of applied sciences was established in 1994, consists of two counties—the city Hof (county ID 9464) and the rural county also called Hof (county ID 9475) that encompasses the city Hof. If I exclude the more rural counties that encompass big cities (county ID 9475 in the example above), effects of education expansion on low-skilled workers increase a bit (2.4 percent instead of 2.0 percent in period three) and become clearer. The negative effect on training activity, however, stays stable. Additionally, I see some hints on wage effects of highly skilled and medium-skilled workers in some periods. However, those effects are unstable. Therefore, the absence of a significant effect on wages of those two qualification groups are not reasoned by the fact that I defined my treatment group in a wrong way due to county-level data.

5.2 Heterogeneities

After I confirmed the robustness of my results for the whole sample, I intend to examine how the education expansion affected wages and training activity in the different sectors. To do so, Table 3 shows estimation results for the five largest sectors. Here, I exclude the smallest sectors (agriculture; energy, water supply, and mining) and hotel and non-medical services.

(Table 3 about here)

The positive effects on the median wage of low-skilled workers are confirmed in construction and commerce sectors, which account for about 40 percent of the whole sample. The effects are larger than those in the baseline estimates. The results may be a bit surprising for the sector commerce. The construction sector, however, is very dependent on technology and the hiring of engineers and natural scientists. Additionally, the education expansion also positively affected the wages of medium-skilled workers in the construction sector. On the contrary, wages of medium and highly skilled workers are negatively affected in the commerce sector and wages of highly skilled workers are positively affected in the transport and communication sectors as well as financial and insurance institutions. Therefore, the empirical results are heterogeneous with respect to the economic sector of the establishments, particularly for wages of highly skilled workers. Evidence for negative wage effects for low-skilled workers cannot be found in any economic sector.

The negative effects of training activity found in my baseline estimates are mainly driven by the manufacturing sector, which accounts for about 30 percent of the whole sample. In addition, the commerce sector as well as financial and insurance institutions indicate reduced training activity, in particular for the extensive margin.

5.3 Labor Demand and Supply Driven Effects on Training Activity

The foundation of a higher education institute decreases the probability to hire new apprentices and the number of hired apprentices. A decline in training activity may be because school graduates prefer to study rather than opt for an apprenticeship after a higher education institute is established (supply-driven factor). Another explanation is that establishments increase their demand for graduates of the new higher education institutes and decrease their demand for workers with apprenticeship training (demand-driven factor). The decline in training activity illustrated can be observed in the first period shortly after the foundation of the higher education institutes. This fact presuambly supports the first explanation because the first graduates of the newly established higher education institutes take time to enter the labor market. However, Figure 6 also shows that the effect size increases particularly in the fourth year after the higher education institutes are established. This could be interpreted in support for the second explanation.

To analyze the question described in Hypothesis H5 in detail, I use a second dataset. The Linked-Employer-Employee-Data of the IAB (Cross Sectional Model 2, LIAB QM2, DOI: 10.5164/IAB.LIABQM29321.de.en.v1) links administrative information on establishments from the BHP used above and survey information of the IAB Establishment Panel (Ruf et al., 2023).[13] The IAB Establishment Panel provides further information on training activity, including the number of offered slots for apprenticeship training, how many slots could be filled with apprentices, and how many slots remained vacant. As the formulation of the training-related questions changed in the survey across years, I used the years 1993 until 1997 for my analyses.[14] For the indicators on vacant slots in apprenticeship training, I only used years until 1996. Moreover, the sample size is much smaller in the survey data ($N = 1,117$ for 1993–1997) than in the administrative dataset. Table A.2 in Appendix summarizes indicators on training activity by treatment status where I distinguish overall slots in apprenticeship training offered by establishments, filled slots, and vacant slots.

(Figure 7 about here)

Figure 7 provides the empirical results considering the new outcomes of training activity. Due to the limited time horizon, I only display estimates from two years before a higher education institute is established until the third year after the treatment. First, the figure reproduces estimates regarding the number of newly hired apprentices (Panels a and b). Again, the establishment of higher education institutes significantly reduces the number of newly hired apprentices; however, the effect is only significant in the second year after the treatment. In addition, the effect size as well as the standard errors increase as a result of the reduced sample size. I, therefore, do not interpret the magnitude of the coefficients. In Panel c, I consider the slots in apprenticeship training relative to the overall number of employees in the establishment, where no significant effect emerges. The same results appear when I model the absolute number of slots in apprenticeship training, which I omitted from the figure. Apparently, establishments did not substitute apprentices or slots in apprenticeship training

[13] Data access was provided via on-site use at the Research Data Centre (FDZ) of the German Federal Employment Agency (BA) at the Institute for Employment Research (IAB) and via remote data access.

[14] Because survey questions on training activity are asked retrospectively and refer to the previous year of training, this time period provides two pre-treatment years before 1994.

by highly skilled graduates from the newly established higher education institutes. In Panels d–f, I consider the vacant slots in apprenticeship training and notice that two years after the treatment, the probability of having vacant slots significantly increases. The same is visible in Panel f for the number of vacant slots relative to the number of new apprentices. Additional results omitted from the figure confirm this result for the number of vacant slots relative to the number of slots in apprenticeship training offered by the establishments. However, these results are only statistically significant in period 2 and are not confirmed in the subsequent periods. Those results seem to confirm thoughts that the education expansion made it more difficult for establishments to fill slots in apprenticeship training as school graduates are more likely to study instead of beginning an apprenticeship training. However, due to the large standard errors and small sample size, these results should be considered with caution. Moreover, the analysis horizon is more narrowed. Therefore, I could not analyze the role of the labor demand channel in the long term, that is, whether establishments reduced slots of apprenticeship training and substituted training slots by highly school graduates of higher education institutes due to the education expansion.

6 Conclusion

Universities, including those of applied sciences, are crucial in the interaction of technology, innovation, and economic progress. Higher education institutes educate prospective workers, equip them with the most recent technological knowledge, and attract firms and workers to regions. This substantially influences the economic and societal development of regions.

However, in industrialized countries with aging societies, the large share of school graduates starting to study is being considered as critical. In Germany, some policymakers believe that the rising trend to study rather than starting apprenticeship training is causing present large labor shortage.

I consider this question in detail by considering the quasi-experimental establishment of higher education institutes in Bavaria since the 1970s and in particular in the 1990s. By analyzing establishment-level data, I find that establishments decreased their training activity in the course of the education expansion, which is driven by a shift in the school graduates' educational decisions. I also find that the education expansion significantly increases wages of low-skilled workers while the employment of low-skilled and medium-skilled workers is not significantly affected. Therefore, I conclude that the inflow of highly skilled workers that have recently graduated and are equipped with latest knowledge on technologies and innovations can unfold positive spillover effects on other workers. Public debates often ignore such spillover effects. The critical view of the educational decisions of young people is therefore too narrow-minded and do not consider the full range of effects following education expansions.

Further analyses illustrate that wages of highly skilled workers are not significantly reduced. Although this could be possible following economic theory, as my results show that the employment of highly skilled workers, particularly of engineers and natural scientists, increases. However, I see that my results are consistent with those of Lehnert et al. (2020), Berlingieri et al. (2022), and Schultheiss et al. (2023). Moreover, there is a large degree of heterogeneity with respect to the economic sector regarding the effects on wages and training activity.

Declarations

Conflict of Interest and Funding

No funding was received for conducting this study and preparing this manuscript. The author has no relevant financial or non-financial interests to disclose. This article does not contain any studies with human participants or animals performed by the author.

Availability of Data

Raw data of the Establishment History Panel (Ganzer et al., 2022) and of the Linked-Employer-Employee-Data of the IAB (Ruf et al., 2023) are generated by the Research Data Centre (FDZ) of the Federal Employment Agency (BA) at the Institute for Employment Research (IAB). The data can be accessed on-site at the Research Data Centre (FDZ) of the Federal Employment Agency (BA) at the Institute for Employment Research (IAB) or via remote data access at the FDZ. The working sample is not available from the author because of data protection regulations and because the data include sensitive variables such as the place of residence at the level of counties.

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Figures and Tables

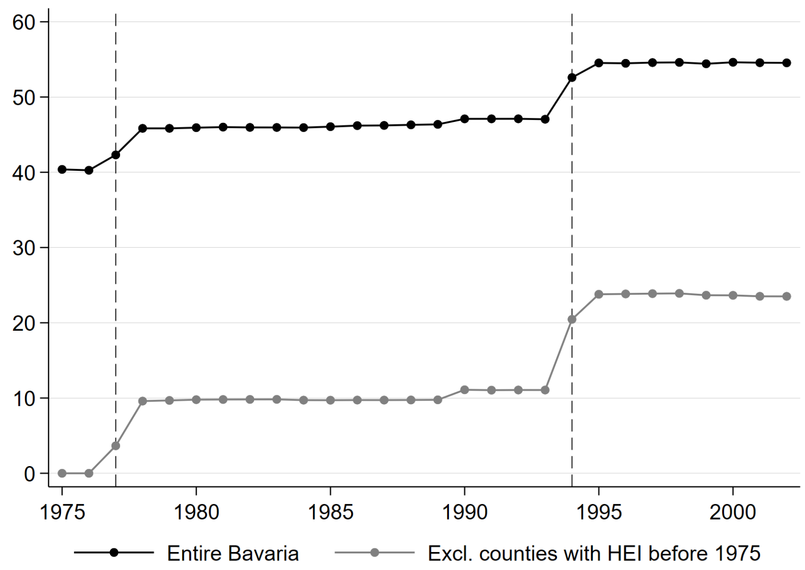
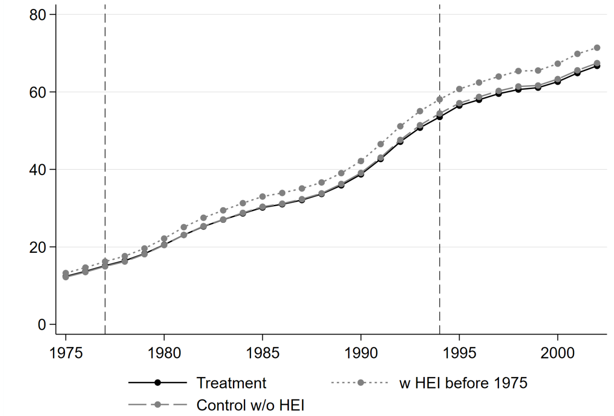
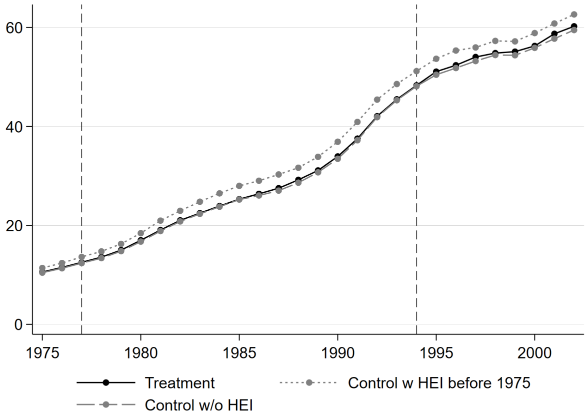


Figure 1 – The Share of Establishments Located in Counties with a Higher Education Institute (HEI) by Years (in %)

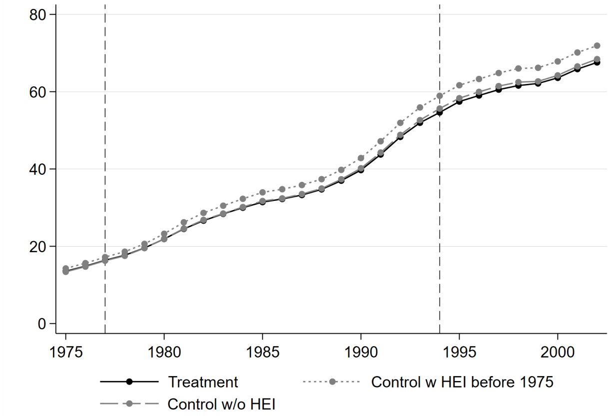
Notes: The figure displays the share of establishments located in counties with a higher education institute (HEI). The two vertical dashed lines mark the beginning of the two waves of education expansion under study in 1977 and 1994.
Source: Establishment-History-Panel (BHP 7521); Higher Education Compass; Federal Statistical Office (several issues).



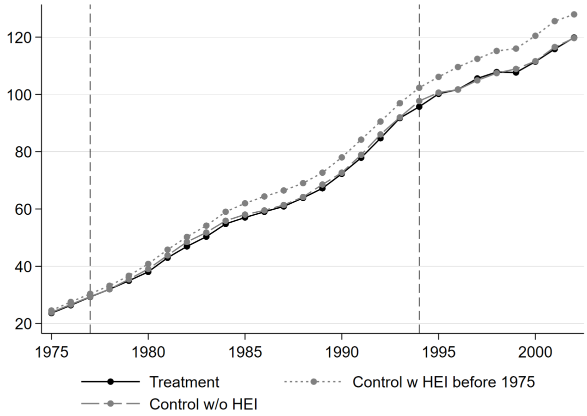
(a) Median wage (in €)



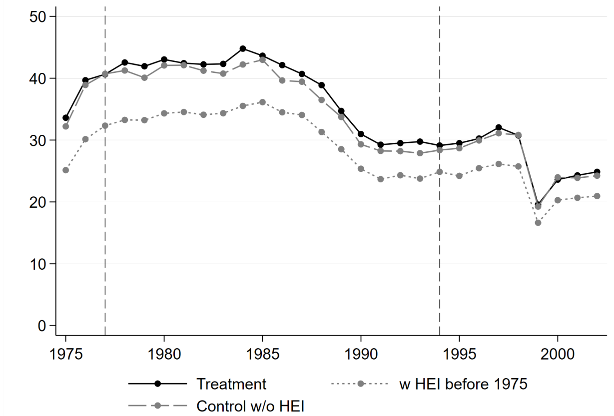
(b) Median wage of low-skilled (in €)



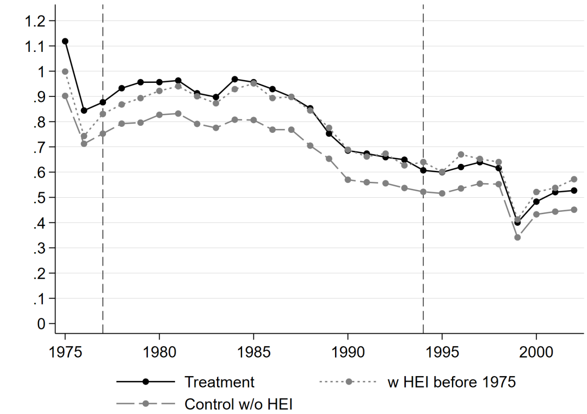
(c) Median wage of medium-skilled (in €)



(d) Median wage of highly skilled (in €)



(e) Share of establishments hiring at least one new apprentice (in %)



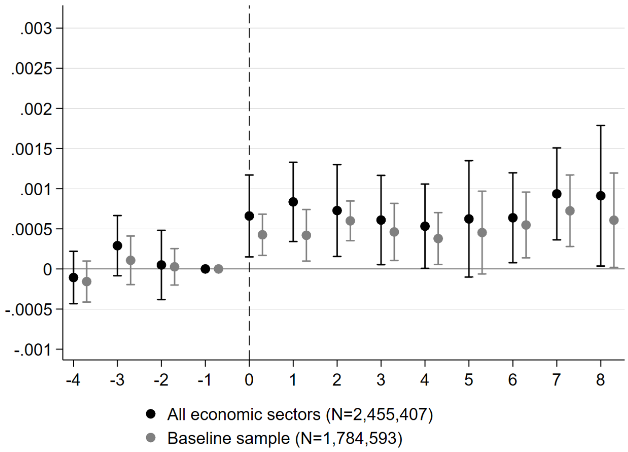
(f) Number of new apprentice

Figure 2 – Median Wages and Training Activity by Treatment Status and Years

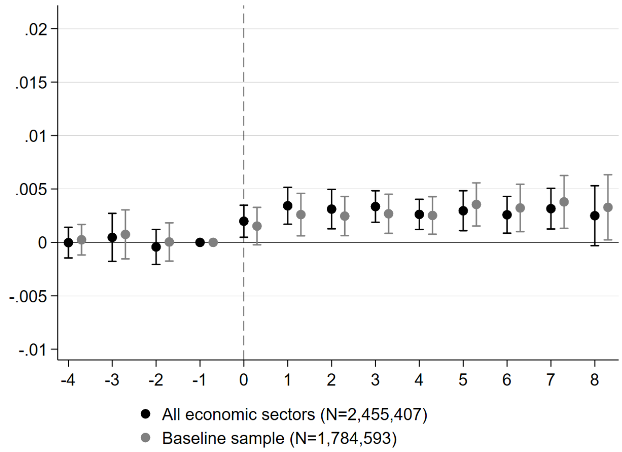
Notes: The figure displays median wage and training activity for three groups: the treatment group where a higher education institute (HEI) was established after 1975, the control group where no higher education institute had been ever established, and counties where a higher education institute had been established before 1975. The two vertical dashed lines mark the beginning of the two waves of education expansion under study in 1977 and 1994.

Source: Establishment-History-Panel (BHP 7521); Higher Education Compass; Federal Statistical Office (several issues).

A: Period 1975–2002

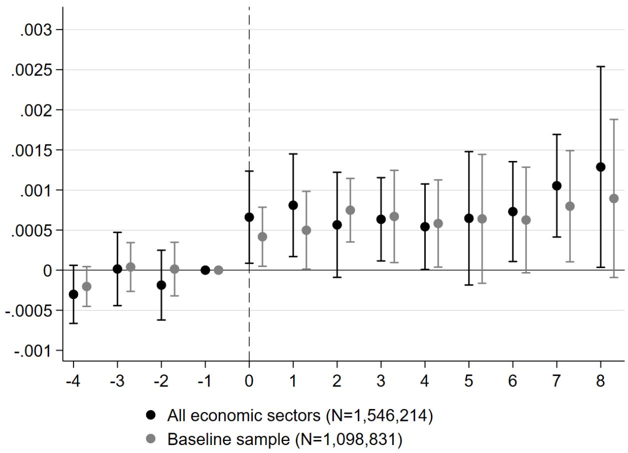


(a) Share of ENS relativ to all employees

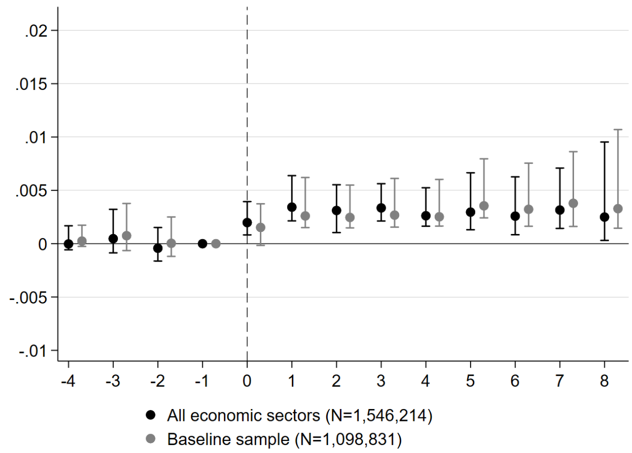


(b) Share of establishments with ENS

B: FBO I period (1985-2002)



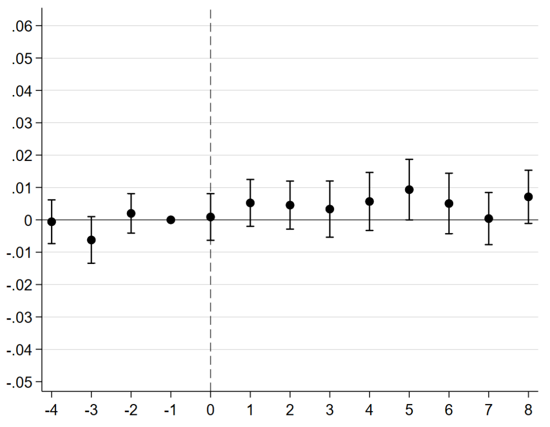
(c) Share of ENS relativ to all employees



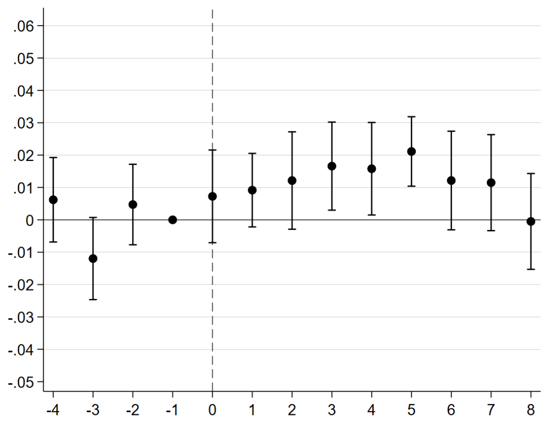
(d) Share of establishments with ENS

Figure 3 – Treatment Effects on the Hiring of Engineers and Natural Scientists (ENS)

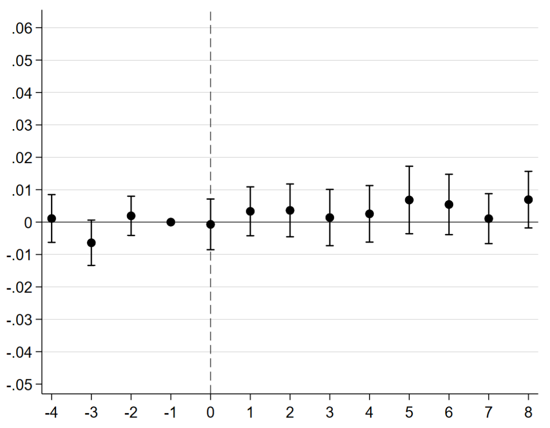
Notes: The figure displays dynamic treatment effects of establishing a new higher education institute in period $\tau = 0$ on the hiring of engineers and natural scientists in pre-treatment and post-treatment periods by using the estimator by Sun and Abraham (2021). Never-treated establishments are used as the control group and the period one year before the treatment is used as the reference period. Confidence intervals are calculated for the 95 percent level. Each estimate presented here controls for variables listed in equation 1, which are fixed effects for years, economic sector, county and covariates describing the size of an establishment. Standard errors are clustered at the level of counties.
Source: Establishment-History-Panel (BHP 7521); Higher Education Compass; Federal Statistical Office (several issues).



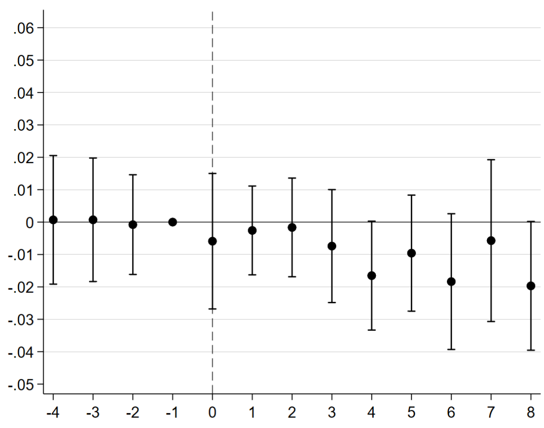
(a) Median wage ($N = 1,580,717$)



(b) Median wage of low-qualified ($N = 542,371$)



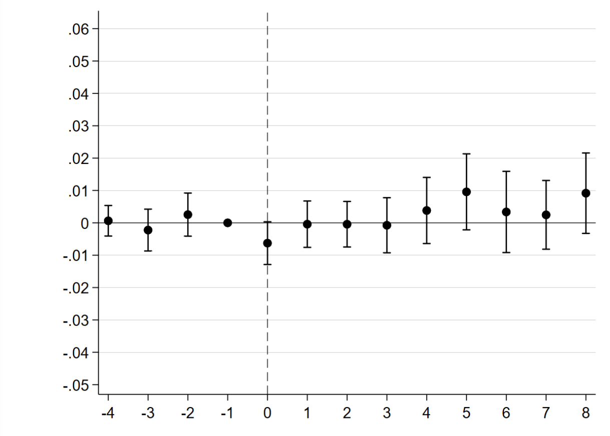
(c) Median wage of medium-qualified ($N = 1,474,368$)



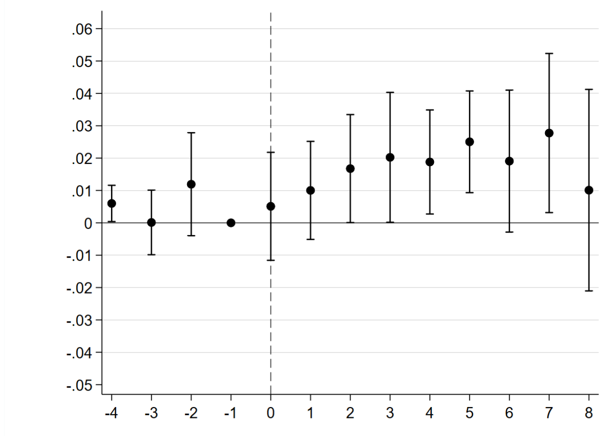
(d) Median wage of highly qualified ($N = 132,001$)

Figure 4 – Treatment Effects on Wages for the Period 1975-2002

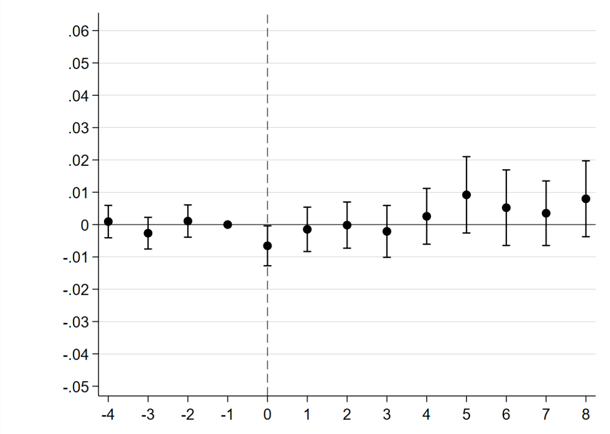
Notes: The figure displays dynamic treatment effects of establishing a new higher education institute in period $\tau = 0$ on establishment-level outcomes in pre-treatment and post-treatment periods by using the estimator by Sun and Abraham (2021). Never-treated establishments are used as the control group and the period one year before the treatment is used as the reference period. Confidence intervals are calculated for the 95 percent level. Each estimate presented here controls for variables listed in equation 1, which are fixed effects for years, economic sector, county and covariates describing the size of an establishment. Standard errors are clustered at the level of counties.
Source: Establishment-History-Panel (BHP 7521); Higher Education Compass; Federal Statistical Office (several issues).



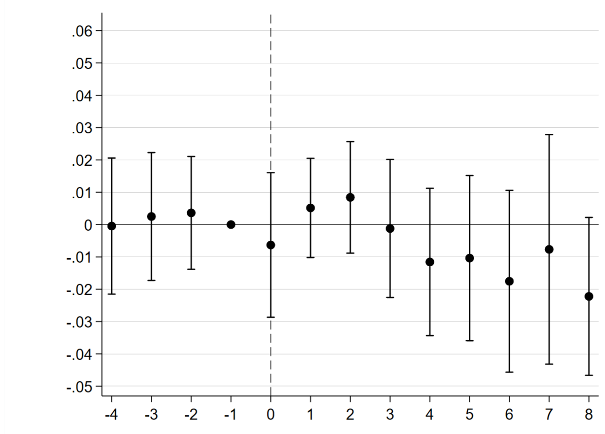
(a) Median wage ($N = 952,958$)



(b) Median wage of low-qualified ($N = 270,747$)



(c) Median wage of medium-qualified ($N = 903,232$)

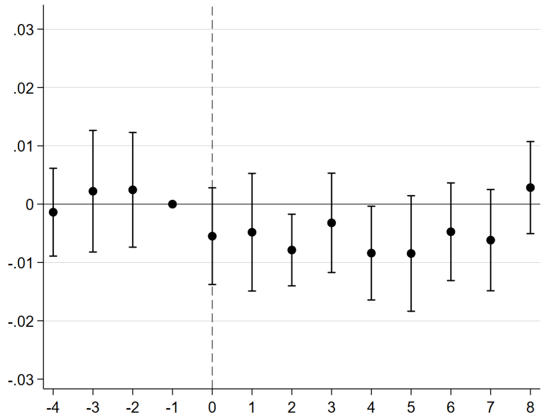


(d) Median wage of highly qualified ($N = 91,399$)

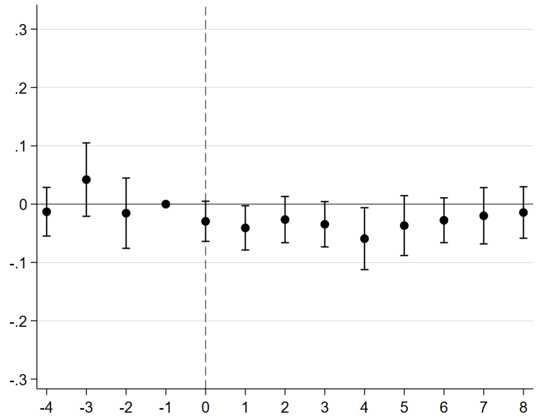
Figure 5 – Treatment Effects on Wages for the FBO I period (1985-2002)

Notes: The figure displays dynamic treatment effects of establishing a new higher education institute in period $\tau = 0$ on establishment-level outcomes in pre-treatment and post-treatment periods by using the estimator by Sun and Abraham (2021). Never-treated establishments are used as the control group and the period one year before the treatment is used as the reference period. Confidence intervals are calculated for the 95 percent level. Each estimate presented here controls for variables listed in equation 1, which are fixed effects for years, economic sector, county and covariates describing the size of an establishment. Standard errors are clustered at the level of counties.
Source: Establishment-History-Panel (BHP 7521); Higher Education Compass; Federal Statistical Office (several issues).

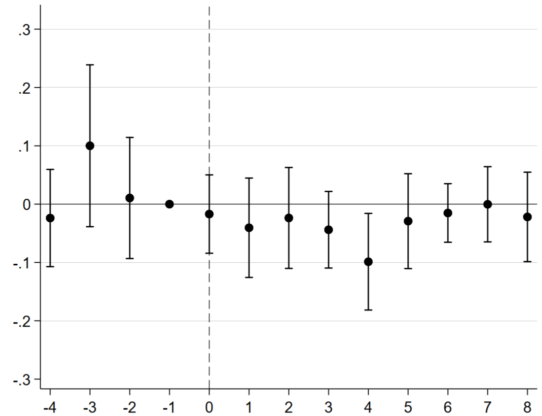
A: Period 1975–2002



(a) Prob. of hiring new apprentices ($N = 1,068,191$)

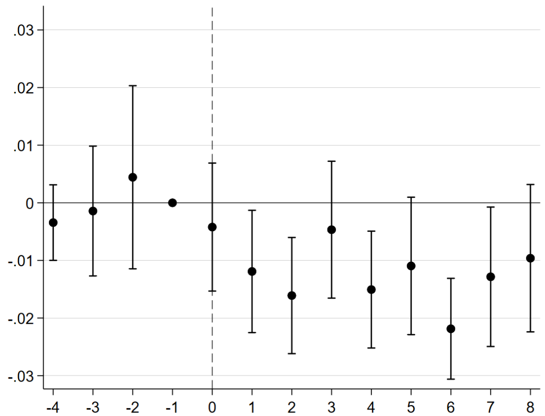


(b) Number of new apprentices ($N = 1,068,191$)

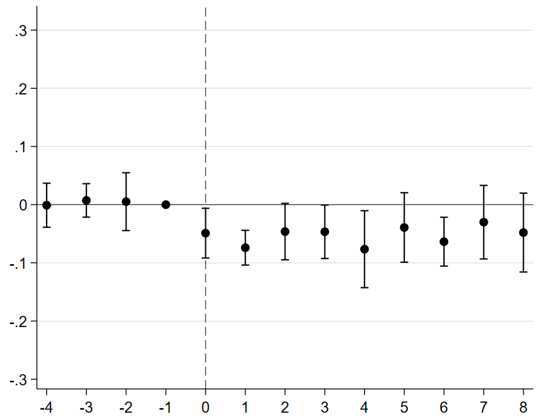


(c) Number of new apprentices (excl. zeros; $N = 446,872$)

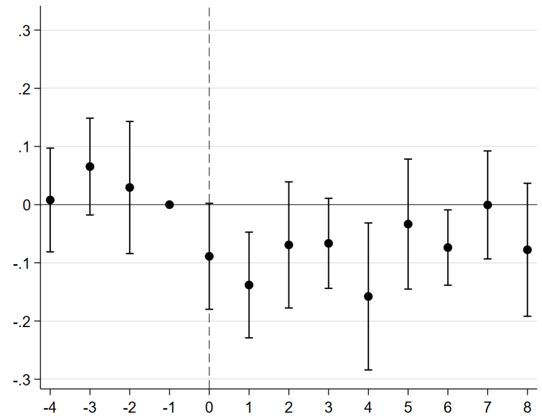
B: FBO I Period (1975–2002)



(d) Prob. of hiring new apprentices ($N = 579,074$)



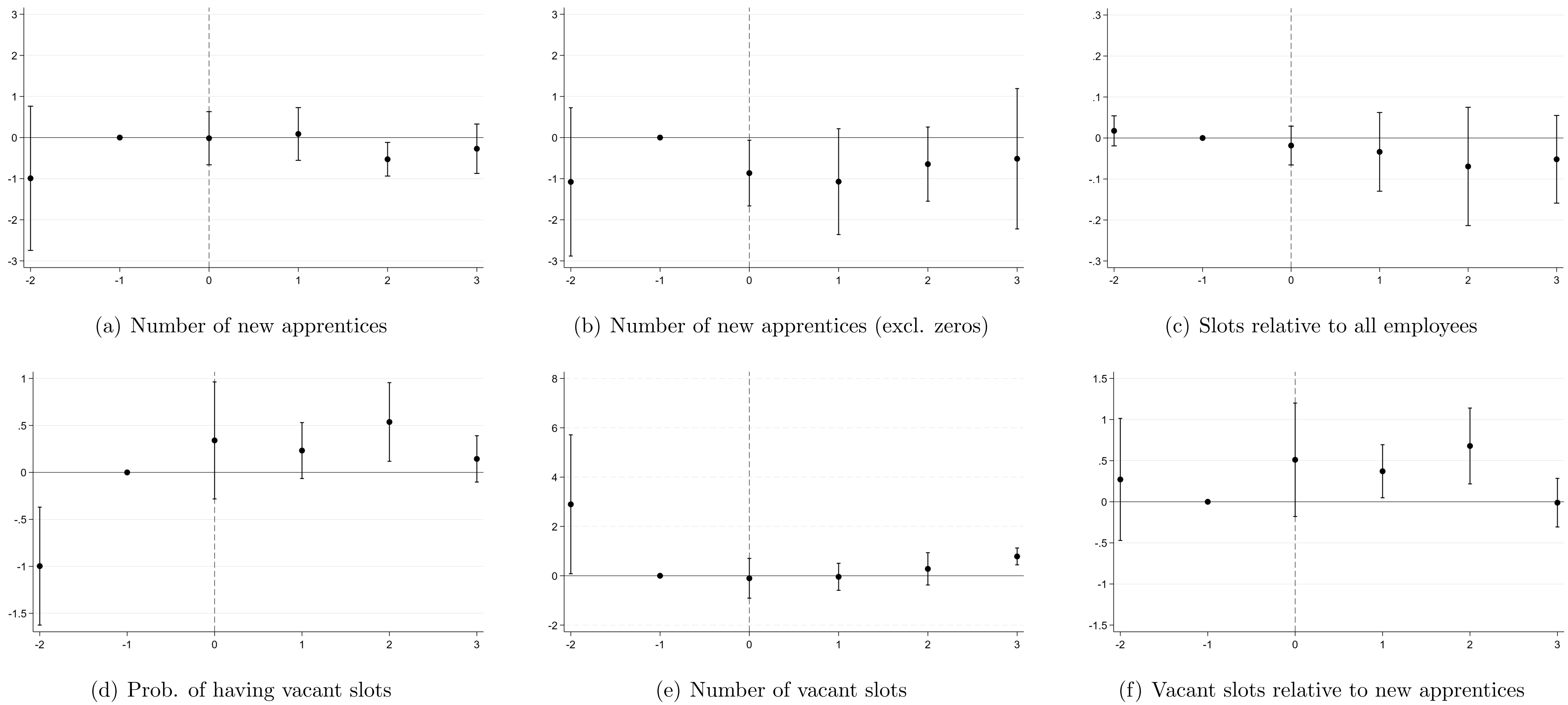
(e) Number of new apprentices ($N = 579,074$)



(f) Number of new apprentices (excl. zeros; $N = 235,337$)

Figure 6 – Treatment Effects on Training Activity

Notes: The figure displays dynamic treatment effects of establishing a new higher education institute in period $\tau = 0$ on establishment-level outcomes in pre-treatment and post-treatment periods by using the estimator by Sun and Abraham (2021). Never-treated establishments are used as the control group and the period one year before the treatment is used as the reference period. Confidence intervals are calculated for the 95 percent level. Each estimate presented here controls for variables listed in equation 1 which are fixed effects for years, economic sector, county and covariates describing the size of an establishment. Standard errors are clustered at the level of counties.
Source: Establishment-History-Panel (BHP 7521); Higher Education Compass; Federal Statistical Office (several issues).



(a) Number of new apprentices

(b) Number of new apprentices (excl. zeros)

(c) Slots relative to all employees

(d) Prob. of having vacant slots

(e) Number of vacant slots

(f) Vacant slots relative to new apprentices

Figure 7 – Treatment Effects on Further Indicators of Training Activity for the Period 1993–1997

Notes: The figure displays dynamic treatment effects of establishing a new higher education institute in period $\tau = 0$ on establishment-level outcomes in pre-treatment and post-treatment periods by using the estimator by Sun and Abraham (2021). Never-treated establishments are used as the control group and the period one year before the treatment is used as the reference period. Confidence intervals are calculated for the 95 percent level. Each estimate presented here controls for variables listed in equation 1, which are fixed effects for years, economic sector, county and covariates describing the size of an establishment. Standard errors are clustered at the level of counties and estimations are weighted by cross-sectional projection factors.
Source: Linked-Employer-Employee-Data of the IAB, Cross Sectional Model 2 (LIAB QM2); Higher Education Compass; Federal Statistical Office (several issues).

Table 1 – Pre-Treatment Outcomes, Establishment Size and Economic Sector by Group

	A: 1975-1976						B: 1990-1993					
	Treatment group		Control group				Treatment group		Control group			
	Counties w a new HEI		Counties w/o a HEI		Counties with a HEI established before 1975		Counties w a new HEI		Counties w/o a HEI		Counties with a HEI established before 1975	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Outcomes												
Engineers and natural scientists (ENS)												
Share of establisments with ENS (in %)	1.8	(13.4)	1.6	(12.6)	2.5	(15.5)	3.0	(17.1)	2.6	(15.9)	3.5	(18.4)
Share of ENS relative to all workers (in %)	0.0007	(0.0100)	0.0012	(0.0216)	0.0022	(0.0281)	0.0023	(0.0291)	0.0025	(0.0311)	0.0048	(0.0461)
Wages, deflated (in €)												
Median	13.1	(5.1)	12.9	(5.0)	14.0	(5.6)	45.9	(19.1)	45.5	(18.9)	48.9	(23.0)
Low qualification	11.1	(5.1)	10.9	(4.8)	12.0	(5.4)	40.3	(18.7)	39.5	(17.6)	43.1	(21.0)
Middle qualification	14.3	(5.0)	14.1	(4.9)	15.0	(5.4)	47.0	(18.6)	46.7	(18.3)	49.6	(21.2)
High qualification	25.2	(7.2)	25.4	(6.7)	26.2	(7.6)	84.2	(34.4)	83.0	(34.7)	87.8	(42.7)
Training activity												
Share of establishments with new apprentice (in %)	34.9	(47.7)	33.6	(47.2)	27.0	(44.4)	30.6	(46.1)	28.6	(45.2)	24.6	(43.1)
Number of new apprentices	1.0	(3.5)	0.9	(2.9)	1.0	(6.0)	0.8	(2.5)	0.6	(2.0)	0.7	(4.1)
Establishment size (in %)												
max. 4 employees	56.3	(49.6)	59.2	(49.2)	56.6	(49.6)	54.0	(49.8)	57.5	(49.4)	55.6	(49.7)
5–10 employees	18.9	(39.2)	19.0	(39.2)	18.9	(39.1)	20.3	(40.2)	20.2	(40.2)	19.7	(39.8)
10–25 employees	13.9	(34.6)	13.1	(33.7)	13.5	(34.2)	14.7	(35.4)	13.9	(34.6)	14.0	(34.7)
25–99 employees	8.3	(27.6)	7.0	(25.5)	8.1	(27.3)	8.2	(27.5)	6.6	(24.8)	7.9	(27.0)
min. 100 employees	2.6	(15.9)	1.8	(13.4)	3.0	(16.9)	2.8	(16.5)	1.8	(13.3)	2.8	(16.4)
Economic sector (in %)												
Agrigulture	2.9	(16.7)	3.5	(18.4)	2.1	(14.2)	2.5	(15.8)	4.3	(20.2)	2.4	(15.3)
Energy, water supply, and mining	0.8	(8.9)	0.9	(9.7)	0.4	(6.3)	0.6	(7.5)	0.7	(8.4)	0.3	(5.7)
Manufacturing industry	33.3	(47.1)	34.4	(47.5)	27.9	(44.9)	31.2	(46.3)	30.7	(46.1)	24.9	(43.2)
Construction sector	12.3	(32.9)	14.2	(34.9)	12.2	(32.7)	11.9	(32.4)	13.5	(34.2)	11.8	(32.2)
Commerce sector	27.3	(44.6)	24.3	(42.9)	33.7	(47.3)	29.3	(45.5)	25.9	(43.8)	34.0	(47.4)
Transport and communication	5.3	(22.4)	5.2	(22.2)	6.3	(24.2)	6.3	(24.3)	6.0	(23.8)	7.2	(25.9)
Financial and insurance institutions	4.0	(19.6)	4.0	(19.7)	3.4	(18.2)	4.1	(19.9)	3.8	(19.1)	3.8	(19.2)
Hotel/catering sector, and non-medical services	14.1	(34.8)	13.5	(34.2)	14.0	(34.7)	14.0	(34.7)	15.0	(35.7)	15.6	(36.3)
Further characteristics considering establishments composition (in %)												
Regular employed workers	89.8	(18.1)	90.0	(17.7)	92.6	(15.4)	93.2	(13.8)	93.4	(13.6)	94.8	(12.3)
Full-time employed workers	86.0	(20.4)	86.3	(20.1)	88.4	(18.7)	84.8	(21.0)	85.4	(20.5)	87.0	(19.6)
Part-time employed workers	3.7	(11.1)	3.5	(10.9)	4.1	(11.6)	8.3	(16.9)	7.9	(16.2)	7.7	(16.0)
Female workers	42.0	(39.7)	41.6	(39.7)	45.7	(39.0)	44.7	(38.4)	44.1	(38.6)	45.7	(38.1)
Workers with non-German citizenship	18.2	(23.6)	17.9	(23.4)	19.3	(25.2)	21.4	(25.7)	21.3	(25.9)	23.9	(28.4)
Low-skilled workers	35.7	(33.3)	36.6	(33.7)	29.1	(31.7)	17.3	(24.0)	17.8	(24.7)	15.2	(23.4)
Medium skilled workers	62.7	(33.6)	61.9	(34.0)	67.8	(32.7)	80.1	(25.6)	79.6	(26.3)	79.9	(26.8)
Highly skilled workers	0.5	(4.2)	0.6	(4.9)	1.3	(7.5)	1.7	(8.7)	1.7	(8.8)	3.5	(13.0)
Observations	23,128		72,489		63,399		33,872		181,231		146,242	
Number of establishments	12,345		38,803		33,934		10,384		55,591		45,420	

Notes: The table displays means and standard deviations (SD) of establishment-level outcomes, establishment size, and economic sector by treatment status. To consider differences before the treatment came into effect, descriptive statistics are given for periods before the respective education expansion started. Therefore, statistics are given for the years 1975 until 1976 in Panel A. For the sample evaluating FBO I, statistics are displayed for the years 1990 until 1993 (Panel B). In Panel B, I excluded those counties where a higher education institute (HEI) was established after 1975 and before 1990.
Source: Establishment-History-Panel (BHP 7521); Higher Education Compass; Federal Statistical Office (several issues).

Table 2 – Sensitivity Analyses

	Median wage		Median wage w.r.t. qualification						Training activity					
			Low		Medium		High		Prob. of hiring new apprentices		No. of new apprentices		No. of new apprentices (> 0)	
	Coeff	SE	Coeff	SE	Coeff	SE	Coeff	SE	Coeff	SE	Coeff	SE	Coeff	SE
A: Excluding establishments with a very large share of marginally employed workers, >70% ($N = 948,674$)														
$\tau = -2$	0.0025	(0.0034)	0.0120	(0.0080)	0.0010	(0.0025)	0.0036	(0.0088)	0.0047	(0.0072)	0.0049	(0.0258)	0.0290	(0.0598)
$\tau = 0$	−0.0064*	(0.0033)	0.0049	(0.0084)	−0.0066**	(0.0031)	-0.0063	(0.0113)	-0.0041	(0.0054)	−0.0509**	(0.0225)	−0.0891*	(0.0464)
$\tau = +1$	-0.0005	(0.0036)	0.0099	(0.0076)	-0.0014	(0.0034)	0.0052	(0.0077)	−0.0122**	(0.0049)	−0.0779***	(0.0158)	−0.1379***	(0.0482)
$\tau = +2$	-0.0003	(0.0036)	0.0165*	(0.0084)	-0.0001	(0.0036)	0.0085	(0.0087)	−0.0180***	(0.0051)	−0.0501*	(0.0253)	-0.0709	(0.0557)
$\tau = +3$	-0.0006	(0.0043)	0.0199*	(0.0101)	-0.0019	(0.0040)	-0.0012	(0.0108)	-0.0073	(0.0060)	−0.0517**	(0.0245)	-0.0632	(0.0403)
$\tau = +4$	0.0042	(0.0051)	0.0191**	(0.0080)	0.0028	(0.0042)	-0.0108	(0.0117)	−0.0177***	(0.0047)	−0.0862**	(0.0358)	−0.1619**	(0.0665)
$\tau = +5$	0.0101*	(0.0058)	0.0243***	(0.0082)	0.0091	(0.0057)	-0.0097	(0.0130)	−0.0125***	(0.0047)	-0.0431	(0.0333)	-0.0299	(0.0569)
B: Excluding rural counties around big cities ($N = 888,614$)														
$\tau = -2$	0.0054*	(0.0029)	0.0211*	(0.0111)	0.0028	(0.0023)	0.0148	(0.0114)	-0.0027	(0.0080)	0.0176	(0.0402)	0.0762	(0.0873)
$\tau = 0$	-0.0049	(0.0036)	0.0142	(0.0115)	−0.0057*	(0.0033)	-0.0124	(0.0152)	−0.0153***	(0.0052)	−0.0804***	(0:0235)	−0.1275***	(0.0599)
$\tau = +1$	0.0014	(0.0044)	0.0160	(0.0107)	0.0014	(0.0039)	0.0164**	(0.0080)	-0.0091	(0.0064)	−0.0985***	(0.0160)	−0.1733***	(0.0662)
$\tau = +2$	0.0006	(0.0045)	0.0240**	(0.0113)	0.0018	(0.0046)	0.0205**	(0.0093)	−0.0286***	(0.0047)	−0.0879***	(0.0206)	−0.1328***	(0.0628)
$\tau = +3$	0.0017	(0.0051)	0.0297**	(0.0143)	0.0020	(0.0045)	0.0077	(0.0092)	-0.0111	(0.0089)	−0.0805**	(0.0315)	−0.0919*	(0.0533)
$\tau = +4$	0.0038	(0.0056)	0.0240***	(0.0091)	0.0039	(0.0039)	-0.0081	(0.0128)	−0.0169***	(0.0048)	−0.1249***	(0.0468)	−0.2200**	(0.0906)
$\tau = +5$	0.0134**	(0.0062)	0.0284***	(0.0090)	0.0146**	(0.0064)	-0.0024	(0.0135)	−0.0141***	(0.0033)	-0.0562	(0.0534)	-0.0222	(0.0827)
C: Initial values of additional covariates ($N = 952,958$)														
$\tau = -2$	0.0025	(0.0034)	0.0119	(0.0080)	0.0011	(0.0025)	0.0036	(0.0088)	0.0050	(0.0071)	0.0051	(0.0257)	0.0291	(0.0599)
$\tau = 0$	−0.0063*	(0.0033)	0.0051	(0.0084)	−0.0066**	(0.0031)	-0.0062	(0.0113)	-0.0038	(0.0055)	−0.0503**	(0.0226)	−0.0889*	(0.0465)
$\tau = +1$	-0.0004	(0.0036)	0.0100	(0.0076)	-0.0015	(0.0035)	0.0051	(0.0077)	−0.0120**	(0.0049)	−0.0775***	(0.0158)	−0.1376***	(0.0483)
$\tau = +2$	-0.0004	(0.0036)	0.0167*	(0.0084)	-0.0002	(0.0036)	0.0085	(0.0087)	−0.0179***	(0.0051)	−0.0495*	(0.0254)	-0.0709	(0.0556)
$\tau = +3$	-0.0007	(0.0043)	0.0202**	(0.0101)	-0.0021	(0.0040)	-0.0012	(0.0107)	-0.0072	(0.0060)	−0.0513**	(0.0244)	-0.0631	(0.0402)
$\tau = +4$	0.0038	(0.0051)	0.0188**	(0.0081)	0.0026	(0.0043)	-0.0115	(0.0115)	−0.0176***	(0.0048)	−0.0855**	(0.0359)	−0.1616**	(0.0662)
$\tau = +5$	0.0096	(0.0059)	0.0250***	(0.0079)	0.0092	(0.0059)	-0.0104	(0.0128)	−0.0124**	(0.0048)	-0.0435	(0.0331)	-0.0299	(0.0570)
D: Standard errors clustered at the establishment level ($N = 952,958$)														
$\tau = -2$	0.0025	(0.0026)	0.0120**	(0.0053)	0.0010	(0.0026)	0.0038	(0.0091)	0.0045	(0.0055)	0.0052	(0.0221)	0.0297	(0.0507)
$\tau = 0$	−0.0065**	(0.0029)	0.0052	(0.0058)	−0.0068**	(0.0028)	-0.0065	(0.0104)	-0.0043	(0.0057)	−0.0490**	(0.0205)	−0.0889*	(0.0460)
$\tau = +1$	-0.0004	(0.0031)	0.0102	(0.0064)	-0.0015	(0.0031)	0.0051	(0.0107)	−0.0115*	(0.0060)	−0.0734***	(0.0231)	−0.1376***	(0.0503)
$\tau = +2$	-0.0003	(0.003)	0.0170**	(0.0065)	-0.0001	(0.0033)	0.0084	(0.0115)	−0.0160***	(0.0059)	−0.0463*	(0.0247)	-0.0690	(0.0503)
$\tau = +3$	-0.0009	(0.0035)	0.0201***	(0.0068)	-0.0023	(0.0035)	-0.0013	(0.0119)	-0.0048	(0.0062)	−0.0469*	(0.0244)	-0.0665	(0.0515)
$\tau = +4$	0.0037	(0.0038)	0.0191**	(0.0077)	0.0024	(0.0037)	-0.0119	(0.0138)	−0.0151***	(0.0059)	−0.0764***	(0.0232)	−0.1577***	(0.0479)
$\tau = +5$	0.0096**	(0.0039)	0.0255***	(0.0081)	0.0092**	(0.0040)	-0.0100	(0.0138)	−0.0108*	(0.0056)	-0.0392	(0.0290)	-0.0330	(0.0681)

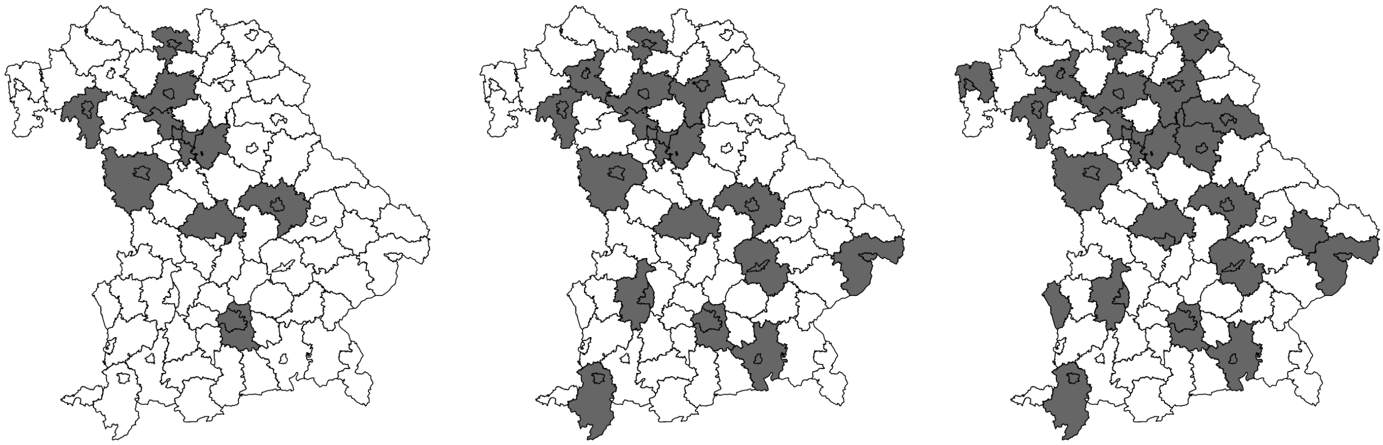
Notes: Stars denote significance of coefficients: $^{*}p < 10\%$, $^{**}p < 5\%$, $^{***}p < 1\%$.
The table displays dynamic treatment effects of establishing a new higher education institute in period $\tau = 0$ on establishment-level outcomes in pre-treatment and post-treatment periods by using the estimator by Sun and Abraham (2021) and considering the period 1985-2002. Never-treated establishments are used as the control group and the period one year before the treatment is used as the reference period. Each estimate presented here controls for variables listed in equation 1 which are fixed effects for years, economic sector, county and covariates describing the size of an establishment. Standard errors are clustered at the level of counties (except in Panel D). This table changes estimation respectively in one aspect to check robustness. In Panel A, I exclude establishments with a very large share of marginally employed workers (>70 percent). In Panel B, I excluded rural counties around big cities. In Panel C, I add further initial values of further control variables (form of employment, gender, and foreign share). In Panel D, I cluster standard errors at the establishment level rather than at the county level. The displayed number of observations refers to the estimation using outcome median wage as the outcome.
Source: Establishment-History-Panel (BHP 7521); Higher Education Compass; Federal Statistical Office (several issues).

Table 3 – Effects on Higher Education in Economic Sectors

	Median wage		Median wage w.r.t. qualification						Training activity					
			Low		Medium		High		Prob. of hiring new apprentices		No. of new apprentices		No. of new apprentices (> 0)	
	Coeff	SE	Coeff	SE	Coeff	SE	Coeff	SE	Coeff	SE	Coeff	SE	Coeff	SE
A: Manufacturing industry ($N = 289,198$)														
$\tau = 0$	−0.0067*	(0.0039)	-0.0075	(0.0158)	-0.0053	(0.0041)	0.0120	(0.0093)	-0.0037	(0.0110)	−0.1478***	(0.0485)	−0.2527***	(0.0841)
$\tau = +1$	-0.0088	(0.0058)	-0.0031	(0.0143)	-0.0045	(0.0052)	0.0128	(0.0124)	−0.0217**	(0.0087)	−0.2007***	(0.0389)	−0.3115***	(0.0814)
$\tau = +2$	-0.0059	(0.0058)	0.0012	(0.0141)	-0.0044	(0.0065)	0.0117	(0.0122)	-0.0157	(0.0106)	−0.1071**	(0.0434)	-0.1069	(0.0773)
$\tau = +3$	−0.0089*	(0.0053)	-0.0013	(0.0137)	-0.0057	(0.0053)	0.0053	(0.0130)	-0.0039	(0.0126)	−0.1157***	(0.0300)	−0.1715***	(0.0580)
$\tau = +4$	-0.0040	(0.0075)	0.0083	(0.0159)	-0.0044	(0.0067)	-0.0114	(0.0216)	−0.0300***	(0.0085)	−0.1591***	(0.0551)	−0.2582***	(0.0913)
$\tau = +5$	0.0013	(0.0070)	0.0131	(0.0135)	-0.0026	(0.0074)	0.0043	(0.0142)	-0.0185	(0.0114)	-0.0989	(0.0641)	-0.1328	(0.1093)
B: Construction sector ($N = 129,323$)														
$\tau = 0$	0.0097*	(0.0056)	0.0417**	(0.0127)	0.0032	(0.0054)	0.0055	(0.0198)	0.0024	(0.0153)	0.0021	(0.0302)	0.0201	(0.0648)
$\tau = +1$	0.0105*	(0.0057)	0.0135	(0.0212)	0.0063	(0.0053)	0.0290	(0.0245)	0.0022	(0.0129)	0.0120	(0.0335)	0.0105	(0.0554)
$\tau = +2$	0.0136**	(0.0056)	0.0289*	(0.0164)	0.0124*	(0.0069)	0.0096	(0.0214)	-0.0183	(0.0143)	-0.0137	(0.0467)	-0.0063	(0.0816)
$\tau = +3$	0.0085*	(0.0047)	0.0345**	(0.0158)	0.0074	(0.0066)	-0.0067	(0.0254)	0.0060	(0.0181)	0.0053	(0.0408)	0.0456	(0.0674)
$\tau = +4$	0.0048	(0.0093)	0.0293	(0.0200)	0.0021	(0.0100)	0.0012	(0.0271)	0.0094	(0.0183)	-0.0099	(0.0449)	0.0020	(0.0771)
$\tau = +5$	0.0192**	(0.0083)	0.0244**	(0.0120)	0.0205**	(0.0086)	-0.0164	(0.0251)	0.0153	(0.0168)	0.0393	(0.0301)	0.0580	(0.0545)
C: Commerce sector ($N = 249,860$)														
$\tau = 0$	−0.0174***	(0.0053)	0.0150	(0.0168)	−0.0204***	(0.0054)	-0.0251	(0.0185)	-0.0002	(0.0086)	0.0177	(0.0119)	0.0636	(0.0420)
$\tau = +1$	-0.0030	(0.0059)	0.0336**	(0.0140)	-0.0088	(0.0055)	0.0048	(0.0132)	-0.0055	(0.0107)	0.0135	(0.0283)	0.0633	(0.0826)
$\tau = +2$	−0.0084*	(0.0045)	0.0400***	(0.0151)	−0.0140***	(0.0046)	0.0125	(0.0257)	−0.0194*	(0.0104)	-0.0298	(0.0208)	-0.0772	(0.0597)
$\tau = +3$	-0.0061	(0.0064)	0.0410**	(0.0167)	−0.0132*	(0.0069)	-0.0219	(0.02158)	−0.0180***	(0.0065)	0.0176	(0.0214)	0.0547	(0.0467)
$\tau = +4$	-0.0023	(0.0082)	0.0403*	(0.0213)	-0.0062	(0.0060)	−0.0446**	(0.0214)	−0.0187**	(0.0083)	-0.0295	(0.0215)	-0.0258	(0.0648)
$\tau = +5$	0.0065	(0.0098)	0.0403*	(0.0207)	0.0042	(0.0085)	−0.0612***	(0.0226)	−0.0146*	(0.0081)	0.0027	(0.0220)	0.0661	(0.0771)
D: Transport and communication ($N = 60,425$)														
$\tau = 0$	−0.0097*	(0.0049)	0.0017	(0.0148)	-0.0040	(0.0056)	-0.1058	(0.1112)	-0.0005	(0.0129)	0.0165	(0.0658)	0.3420	(0.3180)
$\tau = +1$	-0.0043	(0.0089)	0.0025	(0.0209)	-0.0076	(0.0081)	-0.0355	(0.0449)	-0.0143	(0.0106)	0.0098	(0.0735)	0.3187	(0.3696)
$\tau = +2$	0.0058	(0.0088)	0.0100	(0.0192)	0.0037	(0.0087)	-0.0287	(0.0431)	-0.0062	(0.0109)	0.1376**	(0.0626)	0.4538	(0.3103)
$\tau = +3$	0.0113	(0.0099)	0.0267*	(0.0134)	0.0052	(0.0101)	0.0494	(0.0526)	0.0073	(0.0148)	-0.0680	(0.1483)	0.1650	(0.2531)
$\tau = +4$	0.0187	(0.0135)	0.0165	(0.0214)	0.0097	(0.0136)	0.0199	(0.0565)	-0.0014	(0.0136)	-0.0088	(0.1703)	-0.2876	(0.4013)
$\tau = +5$	0.0107	(0.0142)	0.0277	(0.0232)	0.0056	(0.0135)	0.0888**	(0.0426)	0.0060	(0.0135)	0.0268	(0.1506)	0.6744**	(0.3111)
E: Financial and insurance institutions ($N = 37,051$)														
$\tau = 0$	0.0156*	(0.0080)	0.0304	(0.0230)	0.0158*	(0.0073)	0.0448	(0.0321)	−0.0467*	(0.0250)	-0.0549	(0.0677)	0.1924	(0.2221)
$\tau = +1$	0.0078	(0.0084)	0.0194	(0.0290)	0.0119	(0.0083)	0.0493	(0.0310)	-0.0292	(0.0340)	-0.0590	(0.0610)	0.0689	(0.1618)
$\tau = +2$	0.0062	(0.0099)	0.0451	(0.0347)	0.0169*	(0.0089)	0.0617	(0.0401)	−0.0645**	(0.0303)	-0.0399	(0.0595)	0.2856	(0.2518)
$\tau = +3$	-0.0040	(0.0142)	-0.0060	(0.0332)	0.0010	(0.0138)	0.0903	(0.0596)	-0.0345	(0.0312)	-0.0718	(0.0696)	0.0400	(0.3170)
$\tau = +4$	-0.0072	(0.0121)	-0.0395	(0.0461)	0.0005	(0.0131)	0.1337**	(0.0646)	-0.0250	(0.0247)	−0.1569***	(0.0485)	-0.1158	(0.1928)
$\tau = +5$	0.0092	(0.0131)	0.0008	(0.0391)	0.0098	(0.0119)	0.1208**	(0.0554)	-0.0356	(0.0283)	-0.0939	(0.0800)	0.1436	(0.3179)

Notes: Stars denote significance of coefficients: $^{*}p < 10\%$, $^{**}p < 5\%$, $^{***}p < 1\%$; standard errors are clustered at the level of counties.
The table displays dynamic treatment effects of establishing a new higher education institute in period $\tau = 0$ on establishment-level outcomes in pre-treatment and post-treatment periods by using the estimator by Sun and Abraham (2021) and considering the period 1985-2002. Never-treated establishments are used as the control group and the period one year before the treatment is used as the reference period. In this table, I stratify regression with respect to economic sectors. The displayed number of observations refers to the estimation using outcome median wage as the outcome.
Source: Establishment-History-Panel (BHP 7521); Higher Education Compass; Federal Statistical Office (several issues).

Appendix



(a) 1969 (b) 1979 (c) 2002

Figure A.1 – The Number of Higher Education Institutes in Bavaria across Decades

Source: Higher Education Compass; Federal Statistical Office (several issues).

Table A.1 – The Number of Freshmen in Universities and Universities of Applied Sciences (UAS)

Name of university/university of applied sciences	Number of freshmen								Year of establishment
	1965/66	1970/71	1975/76	1980/81	1985/86	1990/91	1995/96	1998/99	
Universities									
Augsburg	4	147	765	939	1190	2600	1764	1718	1970
Bamberg	73	56	423	684	740	1492	1185	1174	1647
Bayreuth	-	-	210	628	789	1672	1196	1241	1972
Eichstätt-Ingolstadt (Eichstätt)	-	-	-	371	322	716	468	446	1924
Erlangen-Nürnberg	1332	2223	2871	3107	3426	3904	2642	2773	1743
Munich	3429	3944	5054	5321	5802	5738	4898	4878	1472
Munich, Technical University	1628	2026	2396	2937	3769	3611	2234	3006	1868
Munich, University of Armed Forces	-	-	571	612	816	858	559	680	1973
Regensburg	35	1151	1833	2517	1673	2961	2357	2209	1962
Würzburg	930	1704	1986	2365	1789	2995	2158	1937	1402
Universities being established between 1975 and 1998									
Eichstätt-Ingolstadt (Ingolstadt)	-	-	-	-	-	-	103	168	1990
Passau	38	47	31	537	759	1700	1035	1378	1978
Universities of applied sciences									
Augsburg	-	-	369	532	601	877	637	691	1971
Coburg (Coburg)	-	-	472	454	421	763	461	439	1814
Coburg (Münchberg)	-	-	30	49	88	101	31	37	1814
München	-	-	1829	2121	2561	3280	2324	2189	1971
München, Catholic UAS (Benediktbeuern)	-	-	90	92	78	78	90	87	1909
München, Catholic UAS (Munich)	-	-	187	153	143	159	160	181	1909
Neuendettelsau	32	25	133	85	85	84	60	28	1947
Nuremberg	-	-	1007	1207	1316	1869	1244	1260	1971
Nuremberg, Evangelical UAS	-	-	124	99	98	92	97	136	1927
Regensburg	-	-	668	770	1049	1358	893	955	1971
Rosenheim	-	-	437	549	736	660	667	821	1971
Weihenstephan (Triesdorf)	-	-	40	53	78	71	123	131	1971
Weihenstephan (Schönbrunn)	-	-	311	88	85	-	-	-	1971
Weihenstephan (Weihenstephan)	-	-	233	257	250	336	409	433	1971
Würzburg-Schweinfurt-Aschaffenburg (Schweinfurt)	-	-	222	237	430	448	184	149	1971
Würzburg-Schweinfurt-Aschaffenburg (Würzburg)	-	-	579	503	665	858	777	719	1971
Universities of applied sciences being established between 1975 and 1998									
Amberg-Weiden (Amberg)	-	-	-	-	-	-	29	114	1994
Amberg-Weiden (Weiden)	-	-	-	-	-	-	69	112	1994
Ansbach	-	-	-	-	-	-	-	117	1996
Deggendorf	-	-	-	-	-	-	156	216	1994
Hof	-	-	-	-	-	-	102	161	1994
Ingolstadt	-	-	-	-	-	-	80	244	1994
Kempten	-	-	-	139	256	539	383	459	1977
Landshut	-	-	-	164	325	539	378	429	1978
Neu-Ulm	-	-	-	-	-	-	112	117	1994
Würzburg-Schweinfurt-Aschaffenburg (Aschaffenburg)	-	-	-	-	-	-	75	141	1995

Source: Higher Education Compass; Federal Statistical Office (several issues).

Table A.2 – Determinants of Treatment Status in the Period 1990-1993 before the Initiation of FBO I

	(1)	(2)	(3)	(4)
Population (in 1,000 inhabitants)	-0.0177^{*}	0.0026	0.0039	0.0014
	(0.0091)	(0.0089)	(0.0091)	(0.0088)
Population squared	0.0001^{*}	0.00004	0.00001	0.00001
	(0.0001)	(0.00001)	(0.00001)	(0.00001)
Population density		0.0002	0.0003	0.0001
(inhabitants per squared kilometer)		(0.0003)	(0.0004)	(0.0003)
Share of employed to		0.0115^{**}	0.0112^{*}	0.0081
population aged 18-65		(0.0054)	(0.0062)	(0.0085)
School graduates (relative to population		0.0230	0.0859	0.0873
aged 18-65, in 100 graduates per inhabitant)		(0.0290)	(0.0733)	(0.0759)
Vocational pupils (relative		0.0066	0.0025	0.0013
to employable population)		(0.0288)	(0.0292)	(0.0288)
Public debt (relative to		0.0002	0.0001	0.0001
population, in 1,000 Euros per inhabitant)		(0.0002)	(0.0002)	(0.0002)
Public revenue from income tax		-0.00004	-0.00001	-0.00004
(relativ to population)		(0.00003)	(0.00004)	(0.00005)
Composition of workers w. r. t. qualification				
Share of low-skilled workers			0.0129	0.0046
			(0.0268)	(0.0361)
Share of medium-skilled workers			0.0157	0.0095
			(0.0345)	(0.0376)
Share of highly skilled workers			-0.0173	-0.0289
			(0.0545)	(0.0655)
Composition of workers w. r. t. economic sector				
Agriculture				-0.0437
				(0.0466)
Manufacturing sector				0.0451
				(0.0509)
Construction sector				0.0131
				(0.0482)
Energy sector				-0.0607
				(0.0707)
Commerce sector				0.0372
				(0.0595)
Transport and communication sector				0.0657
				(0.0550)
Financial and insurance institutions				0.1007
				(0.1072)
Public sector				0.0869
				(0.0578)
Hotel and non-medical services				0.0406
				(0.0488)
Observations	268	268	268	268
Number of counties	67	67	67	67

Notes: Stars denote significance of coefficients: $^{*}p < 10\%$, $^{**}p < 5\%$, $^{***}p < 1\%$; standard errors in parentheses are clustered at the level of counties.
By applying linear regression, the table regresses a time-invariant treatment dummy on characteristics of counties for the period 1990-1993. The outcome equals one if a new university (of applied sciences) has been founded in a county after 1993 when FBO I came into effect. In the regression, there are therefore only counties included in which no higher education institute was established before 1994. Next to the explaining variables listed above, all four specifications control for years.
Source: Regional database of the Bavarian Statistical Office and of the Federal Empoymnet Agency.

Table A.3 – Indicators of Training Activity Provided in LIAB QM2 by Group for the Period 1993-1997

	Treatment group		Control group		Counties with a HEI established before 1975	
	Counties w a new HEI		Counties w/o a HEI			
	Mean	SD	Mean	SD	Mean	SD
Slots of apprenticeship training						
Slots in apprentice training relative to all employees (in %)	6.3	(33.8)	3.9	(8.7)	7.1	(57.5)
Filled slots of apprenticeship training						
Number of new apprentices	8.3	(23.4)	6.2	(17.9)	10.1	(22.1)
Observations	375		1,014		870	
Number of establishments	126		332		279	
Vacant slots of apprenticeship training						
Share of establishments with vacant slots in apprenticeship traning (in %)	19.5	(39.7)	24.6	(43.1)	22.3	(41.7)
Number of vacant slots in apprenticeship traning	1.3	(5.6)	0.9	(2.6)	1.1	(3.0)
Share of vacant slots in apprenticeship traning relative to new apprentices (in %)	14.2	(39.4)	20.7	(54.3)	19.0	(57.6)
Observations	236		525		488	
Number of establishments	91		203		189	

Notes: The table displays means and standard deviations (SD) of indicators of training activity by treatment status. Descriptive statistics are given for treatment establishments located in counties where a higher education institute (HEI) was established during the observation period, for control establishments located in counties where no higher education institute had ever established, and for establishments located in counties where a higher education institute had been established before the observation period.
Source: Linked-Employer-Employee-Data of the IAB, Cross Sectional Model 2 (LIAB QM2); Higher Education Compass; Federal Statistical Office (several issues).