Vocational Schooling versus Apprenticeship Training — Evidence from Vacancy Data —

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Abstract

How to best prepare non-college bound youth for the labor market? Different approaches compete in this field, including firm-based apprenticeships, full-time vocational schooling, and on-the-job learning. Little is known about how effective these methods are, and comparisons of means are uninformative due to the selection of individuals into different streams. In this paper, we exploit the idea that variation in apprenticeship availability affects the opportunities individuals have when they grow up. We present a small open economy model in which price shocks affect the local number of apprentices, without a differential effect on factor rewards; this motivates an instrumental variable strategy to compare labor market outcomes between labor types, which is implemented exploiting differences in training availability. We document how variation in vacancies for apprenticeships affects educational choice. We show that at the margin, individuals substitute between apprenticeship training and full-time school-based vocational training. We exploit this variation to study how this formation period affects later labor market outcomes at ages 23 to 26. Our results show that firm-based apprenticeship training leads to substantially lower unemployment rates; investigating this pattern over time, the evidence indicates that former apprentices have a transitory advantage which fades out over time. We do not find significant differences in wages. This suggests that these alternatives confer similar overall levels of productivity, and that apprenticeship training improves the early labor market attachment relative to vocational schooling. We investigate the responsiveness to negative shocks in an experiment based on firm closures. Our results are found to be robust in a number of specification checks, and we investigate the validity of our functional form in a semiparametric analysis.

JEL classification: I21, I28, J24, M53.

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1 Introduction

Recent research has emphasized the occupation-specific nature of human capital (Johnson and Keane, 2007; Kambourov and Manovskii, 2008), indicating that human capital is encapsulated in the ability to perform specific tasks. This suggests that the way young labor market entrants are taught the skills they need in the workplace is crucial for their labor market outcomes. At the same time, little is known about how these skills are best conferred. Alternative *templates* (Goldin, 2001) compete with respect to structured vocational training: full-time vocational schooling, largely firm-based apprenticeships[1], and on-the-job training. The co-existence of these alternatives, and the pronounced differences between countries in the approach to vocational training, as documented by Ryan (2001), underlines that no consensus has been reached on how to best equip young people with the skills they are likely to need in the workplace.

In this paper, we compare labor market outcomes between apprenticeship training and full-time vocational schooling, focusing on wages, unemployment and measures of mobility. As identifying source of variation, we exploit the following idea: The apprenticeship system fundamentally links the educational opportunities of young people to the provision of apprenticeship places by firms. Conceptually, the same individual will make different educational choices, depending on where and when she grows up and the corresponding fluctuations in apprenticeship places. Using unique data on apprenticeship vacancies from Germany, together with detailed panel data on labor market outcomes, we document how apprenticeship choice is affected by the availability of apprenticeship places. We show that at the margin, young people substitute between apprenticeship-based training and full-time vocational schooling, rather than between apprenticeship and direct entry as unskilled worker. Thus, the variation we exploit is informative about the relative effect of apprenticeship versus schooling-based training. We then employ this variation in the opportunities of young people as instrumental variable to learn about the causal effect of the apprenticeship scheme. To motivate this instrumental variable, we provide a simple small open economy model with educational choice, in which aggregate price shocks affect the local number of apprentices, but have no differential effect on factor rewards.

Our main results indicate that vocational schools and apprenticeship training provide similar levels of productivity as measured by wages in the age range between 23 and 26. This suggests that these two alternatives are similar in the skills they confer. At the same time, the probability

[1]Ryan (1998) defines *apprenticeship* as 'employer-sponsored programmes which integrate part-time schooling with part-time training and work experience on employers premises [...] within an externally defined curriculum which contains mandatory part-time schooling, leads to a nationally recognised vocational qualification and takes at least two years to complete'.

of unemployment is substantially lower for apprenticeship graduates. Investigating the pattern of unemployment over time, we find that the effect is transitory, and fades out over time. This suggests that apprenticeship training provides a benefit to participants in that it improves labor market attachment early in their career.

We perform our analysis on data for Germany, where full-time vocational schools exist as alternative next to the dual apprenticeship system[2]. This allows us to investigate the relative return in a within-country framework. The early tracking of pupils allows us to abstract from the college-going decision: As we describe below, individuals are tracked at ages 10–12 into either a university-bound upper track or a lower- or medium-schooling track, so that the decision to go to university is already pre-determined through the tracking decision earlier on. With respect to alternative entry as unskilled worker, we treat this as an empirical question, and document in several ways that our measure of apprenticeship availability moves individuals between apprenticeship training and full-time vocational school.

In a policy context, understanding the implications of these different templates is crucial for a number of reasons. Given the increased demand for skilled labor, a well-trained workforce is believed to be central to a productive and competitive economy. In many countries, governments and individuals invest heavily into vocational training schemes, and it is important to know if this money is well spent or could be better invested elsewhere. Vocational schooling plays a large role in many countries: On average across OECD countries, 48% of youth are enrolled in vocational or pre-vocational programs at upper secondary level, of which about a third is a combination of school- and work based programs (OECD, 2008). There is wide variation among countries: In some countries, formal vocational training is entirely or mostly school-based (e.g. Sweden, Belgium), while in others, firm-based programs play an important role (e.g. Denmark, Germany, Switzerland). In the U.S., 16% of high school graduates obtain more than a quarter of their credits in career/technical education (CTE) courses[3], and vocational training plays an important role in community colleges.

Young adults who are not college-bound benefit from knowledge about the effects of taking alternative paths, and from the provision of the most effective training scheme. From a social policy perspective, a well-functioning school-to-work transition can avoid potentially damaging unemployment or inactivity and the social problems associated with that. It is not surprising that this transition is often found at the heart of policy proposals. In a number of cases, policy

[2]The term *dual* refers to the shared provision of training through both the firm and a part-time vocational school, in which the student typically spends one to two days per week.

[3]Source: NCES (2008).

initiatives focus on fostering the role of firms in training young adults through apprenticeship–type programs, as for example in the School-to-Work Opportunity Act of 1994 in the US, or the 1995 Modern Apprenticeship program in the United Kingdom.

Investigating the effects of apprenticeship-type training is of broader importance. The apprenticeship system shares important features with other institutions in different countries and at different educational levels: As Becker (1962) points out, there are essential similarities between apprenticeships and the training of lawyers or physicians. College students around the world attempt to gain practical experience through internships. These activities come at substantial costs to individuals, who work at low or sometimes without pay, and often increase duration of their studies. In the United States, many colleges offer Cooperative Education programs.[4] In a 1996 representative survey of 500 U.S. colleges and universities, the American Council on Education (ACE) finds that 91% of institutions offer unpaid internships, 69% offer paid internships, and 57% offer cooperative education programs (NCCE, 2008b).

Empirically, establishing which of the different templates for vocational skill formation is most effective is difficult because in countries where alternatives coexist, individuals select into the different paths based on individual unobservable characteristics and preferences. Simple comparisons of means between the different paths are likely to be misleading because these characteristics affect labor market outcomes at the same time. These selection problems are well known. Ryan (2001, p.74) highlights these challenges with respect to vocational schooling and firm-based training and concludes that 'a large microeconometric evaluation literature is correspondingly uninformative'. As a result, in trying to understand the implications of the different templates, large emphasis has been placed on evidence from comparative studies. In the comparison of apprenticeship with vocational schooling, the within-country studies which do address selection have regularly relied on excluding family background variables to identify the model, which is difficult to reconcile with the evidence that parental characteristics have a direct effect on a range of parental investments and child outcomes.[5]

Bonnal, Mendes, and Sofer (2002) and Winkelmann (1996) study the transitions immediately after completion of the training period, and find that apprentices are less likely to transit into unemployment. Sollogoub and Ulrich (1999) find that 4.5 years after graduation, apprentices have lower wages (after correcting for selection), but have spent a larger fraction of this

[4]NCCE (2008a) defines *Cooperative Education* as a 'structured educational strategy integrating classroom studies with learning through productive work experiences in a field related to a student's academic or career goals.'

[5]See, for example, Haveman and Wolfe (1995), Currie (2007), and the evidence presented in chapter **??** of this thesis.

period in work. Plug and Groot (1998) find that earnings and earning growth are not statistically different. Blanchflower and Lynch (1994) use the NLSY to estimate the effect of different forms of training on wage growth in a first-difference framework between ages 20 and 25.

This paper makes a number of contributions. The small open economy framework with educational choice provides an economic setting which generates the exclusion restriction that is required for an instrumental variable strategy. We discuss identification in a multinomial choice setting, and argue that a univariate instrument may still recover a well-defined alternative-specific treatment effect in a potentially important special case. We show that in this application, we cannot reject that this condition is satisfied. This allows us to account for selection in a transparent manner, and identify an effect along a clearly defined margin that is of interest to policy-makers. We trace out the differential effect of training form along a number of important labor market outcomes. The panel nature of our administrative data allows to follow individuals for longer than typically possible in school-to-work transition surveys, and provides us with a large representative sample. This paper also empirically investigates the differential responsiveness to negative shocks between apprenticeships and vocational schools, which has been an influential argument in the literature which compares different forms of vocational preparation.

A number of recent papers investigates the role of apprenticeship training along other margins. Comparing apprenticeship training as alternative to on-the-job training, Adda, Dustmann, Meghir, and Robin (2006) estimate a dynamic discrete choice model of apprenticeship choice. The length of vocational training is investigated in Oosterbeek and Webbink (2007) using a reform of compulsory schooling laws, and in Fersterer, Pischke, and Winter-Ebmer (2008), who study the variation of apprenticeship length induced by firm failures. A paper which compares vocational education and academic schooling is the work by Malamud and Pop-Eleches (2008); they do not distinguish between vocational schooling and apprenticeship training.

The paper proceeds as follows: The next section reviews the arguments relating to the relative merits between apprenticeship training versus full-time vocational schooling, and then provides a brief background on the German educational system. Following on, we briefly describe the data. Section 4 addresses identification. Section 5 documents how individuals' educational choice responds to availability of apprenticeship vacancies. Section 6 contains the main results. Section 7 presents a number of sensitivity checks, and the last section concludes.

2 Background

2.1 Differences between apprenticeship training and full-time schooling

In this part we briefly review the main arguments in the comparison between vocational schooling and apprenticeship training.

Schools may be able to provide broader knowledge and more conceptually oriented instruction. This relates to the literature which investigates firm incentives to provide training, starting from the seminal work of Becker (1993). Firms will not invest in the workers' general human capital, since in a competitive labor market the firm will not be able to recover the revenue from this investment. Acemoglu and Pischke (1998) show firms may be willing to provide some general training, since the informational advantage of knowing the worker's quality results in a rent to the firm; but investment in general training is still inefficiently low. A number of authors highlight the role of the apprentice as a form of unskilled worker to the firm. Within the regulatory constraints and contractual commitments to the trainee, firms maximize profits through the use of the apprentice as unskilled worker at low wages (Heckman, 1993). Along similar lines, the employee-type status of the apprentice gives the firm discretion, even given a regulatory framework, and this in turn may lead to commitment problems on the side of the firm. The central drawback of apprenticeship training is that it is thought to be too firm-specific, and may not be sufficiently portable to other firms. The large number of moves young people make in their transition from school to work is well documented (Topel and Ward, 1992), and in the context of technological and structural change, transferability and the ability to acquire further skills are important criteria.

A number of advantages of apprenticeship training are of educational nature. Apprenticeship training is believed to be the more practical approach to learning, which contextualizes knowledge in the workplace. This may be especially relevant for less academically able young adults, and may increase motivation (Ryan (1998, 2001)). School-based instruction relies essentially on a simulated work environment, which may make it harder to link theory and practice. The combination of two learning places in dual systems may on the one hand lead to additional returns from the interaction of two forms of learning. On the other hand, it carries the risk of two unconnected approaches. In terms of skills, apprenticeship training may confer additional work-related skills, like team-work, discipline, the ability to integrate into a working environment and the corresponding working hours and conditions. Firms may know better what skills are required and are more likely to employ the latest technology and practices. Firm involve-

ment in financing training may lead to efficiency gains (Plug and Groot, 1998). Furthermore, apprenticeships may serve a useful function in terms of job search and matching. Firms learn about the quality of the worker, and apprentices also benefit from a reduction of uncertainty about the employer. The on-the-job aspect of apprenticeship training is likely to provide not only more information than can be transferred through certificates, but also information about the specific value of the firm-worker match.

2.2 Institutional background on the German educational system

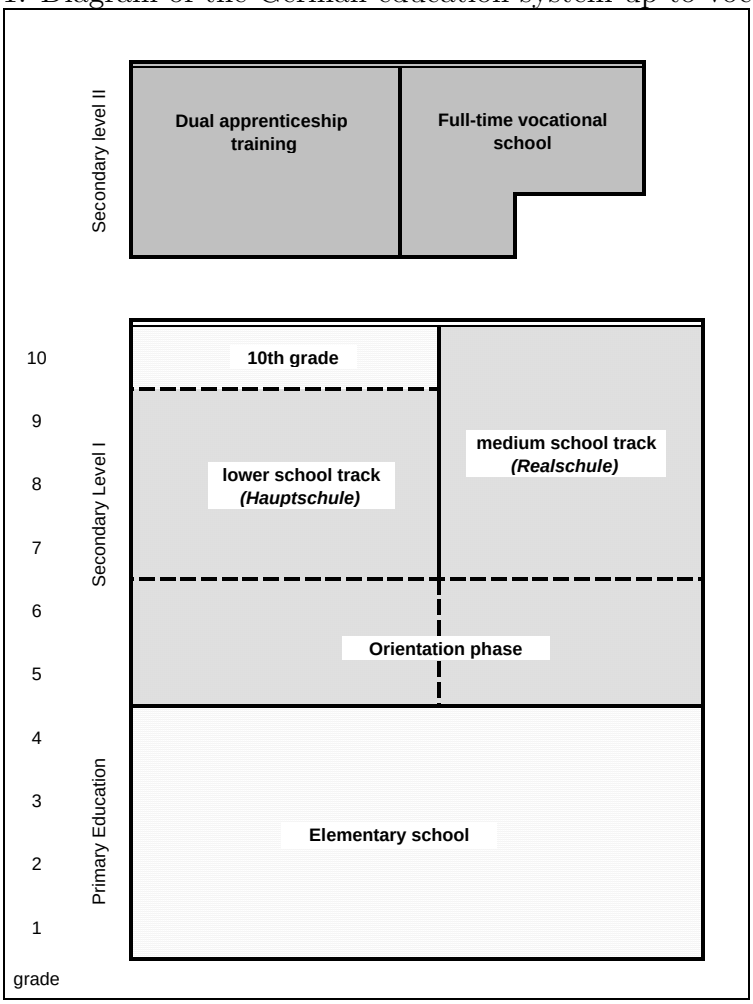
In this section, we provide a brief review of the relevant institutional background in which our study is conducted.[6] When aged between 10 and 12, students are typically tracked into three school streams: the *Gymnasium* as the track for later university students, and the lower and medium school (*Hauptschule* and *Realschule*) leading towards vocational education. Mobility between tracks is rare; since this paper focuses on vocational education, we limit attention to the lower and medium schooling track. Figure 1 shows the structure of the educational and vocational system for these groups. Students complete general secondary school after grade nine or ten, and usually enter vocational education after that. The dual apprenticeship system is particularly well known. In this system, young adults can train and obtain a vocational degree in one of a large number of occupations. Apprenticeships have a full duration of at least two years, with most apprenticeships having a full duration of three, or three and a half years.[7] Apprentices and firms write a contract, which is registered and supervised by the Chambers of Industry and Commerce or the Chamber of Handicrafts. The contract typically specifies an initial probationary period, after which firing from the firm's side is difficult. Apprentices spend about one third of the time in school-based instruction, which typically amounts to one or two days per week and is run by the regional government. Two thirds of the time are spend in the firm, where the apprentice works and the employer provides training. The three most frequent apprenticeship degrees are 'motor vehicle mechatronics technician', 'industrial mechanic', and 'management assistant for retail services'.

Firms can report their apprenticeship vacancies to the local employment office with a request for placement. This typically involves that the firm contacts the employment office and reports their apprenticeship vacancy. The employment office attempts to assist in the matching for this

[6]For further reference, key features of the apprenticeship system in Germany are described in Winkelmann (1996), Soskice (1994), Witte and Kalleberg (1995) and Dustmann (2004). Summary descriptions of the German vocational system can also be found in KMK (2008).

[7]Of the 25 most popular apprenticeship degrees for males in Western Germany in 2004, all but one have a regular duration of at least three years, and only one lasts for two years (data for 2004 for males in Western Germany. Source: Federal Institute for Vocational Education and Training (2006, 2008)).

Figure 1: Diagram of the German education system up to vocational degree



Note: Diagram shows structure of education system up to vocational degree, for individuals streamed into lower and medium schooling track. Own representation based on KMK (2008, Figure 2.4.7). See text for details.

vacancy through advertising it to young adults, and possibly through suggesting candidates to the firm. The firm can then interview the candidate and can, but is under no obligation to do so, offer the apprenticeship to the young adult. The firm is not charged for using this service. Although the firm does not have to report apprenticeship vacancies, this service is regularly used by firms. As an indication, we can compare the number of vacancies reported to the employment office with official statistics on new apprenticeship contracts, on which reliable data is available since apprenticeship contracts need to be specially registered. For example, in the year 1985, which is in the middle of the period we consider here, firms reported 481,000 apprenticeship vacancies in the twelve months up to September 1985. At the end of September, 697,000 new apprenticeship contracts had been registered, and 31,000 apprenticeship vacancies were still unfilled (BA, 1991, Table 45). Hence, vacancies reported to the employment office make up a large share of all apprenticeships.

Full-time vocational schooling is an alternative form of vocational preparation.[8] These schools have a duration ranging from one to three years. One-year vocational courses (*Berufsgrundbildungsjahr* or *Berufsvorbereitungsjahr*) are preparatory courses and do not lead to vocational degrees on their own, but can typically be credited towards further vocational training, especially apprenticeship training. Two or three year courses lead to a recognized occupational certificate, and can lead to the same occupational degrees as apprenticeship training (KMK, 2006). There are a number of vocational degrees which can only be obtained in these full-time vocational schools. These programs lead to a degree as 'assistant' in a range of different occupations. For males, the most common ones are 'technical IT assistant', 'commercial assistant', and 'carer for the elderly'.[9]

In many of the frequently chosen occupational fields, occupation-specific qualifications exist in both the firm-based dual system as in the full-time vocational school. For example, in the field of information technology, young people could obtain an apprenticeship degree as IT specialist in the firm, or a school-based degree as mentioned above. Nonetheless, it is known that the distribution across occupational groups differs between the two training forms; therefore one important sensitivity check investigates how our main results change when we explicitly account for occupation fixed effects.

We conclude this section by briefly reviewing alternative available data sources for the fraction of individuals who obtain different forms of vocational qualification. Official statistics put the shares for highest vocational qualification in Germany at 19% unskilled, 61% dual apprenticeship, and 19% vocational schools.[10] Troltsch et al. (1999) survey the evidence on the share of unskilled youth without formal vocational qualification; estimates range between 10 and 20%. Witte and Kalleberg (1995) report that 16% of men have a school-based vocational education.[11]

3 Data

The analysis in this paper is based on a large administrative panel data set of individual employment histories for German employees, the IABS, provided by the Institute for Employment Research (IAB). The sample contains 2% of all employees who have ever been subject to social

[8] Two main types are the full-time vocational schools (*Berufsfachschulen*) and the schools of health professions (*Schulen des Gesundheitswesens*).

[9] Figures for males from West Germany for 2006, see Federal Statistical Office (2007).

[10] Own calculation based on Federal Institute for Vocational Education and Training (2006), excluding all individuals with college education.

[11] Estimates based on GSOEP. Their sample excludes unskilled workers. For women, the corresponding number in their data is 23%, reflecting the higher proportion of females in schools of health professions.

security contributions over the period 1975 to 2001. We provide details on the data and the sample we use in the Data Appendix A.2, and limit the discussion here to the key aspects. The data contains detailed records of both employment and unemployment spells. Crucially for this paper, it contains not only regular employees, but also records firm-based apprentices. We limit our analysis to West German males (excluding West Berlin) from the cohorts 1964 to 1975.[12] To focus on non-college bound youth we eliminate all individuals who hold a schooling degree from the college-bound schooling track (*Abitur*), or who ever hold a degree from a university (or a university of applied sciences) in our sample. As a measure of where the young adult grows up, we record the first employment office district in which he is recorded in the data.

There are two key educational variables in the data: First, there is a variable which indicates whether the individual has obtained a vocational qualification. This is defined more broadly than firm-based apprenticeship training, and explicitly includes school-based degrees as long as they lead to a recognized vocational qualification.[13] This variable allows us to distinguish unskilled individuals (who might have completed lower or medium-level (general) schooling, but no vocational qualification) from skilled individuals, who have obtained a vocational qualification through completing either apprenticeship or a degree from a full-time vocational school.[14] Second, we compute for each individual the number of years spent in apprenticeship training (up to a given age). Apprenticeship degrees have a regular duration of up to 3.5 years; to reflect that we top-code the number of years of apprenticeship training at this value. This constitutes our main measure of exposure to apprenticeship training. It can be thought of as similar to a years of education measure, but, importantly, it only refers to years spent as apprentice in a firm.[15]

Our main outcomes of interest are unemployment and wages. For unemployment, we take indicator variables for whether the individual has been registered unemployed for at least a given number of days during the calendar year. In our main results, we focus on unemployment for at least 30 days. For wages, we take log average daily wages in regular full-time employment over the calendar year. We also study measures of annual mobility, for which we define indicators for changing industry and occupation, respectively.

[12]We restrict our analysis to males because incorporating fertility decisions would complicate the analysis considerably, which are likely to be important during the age range we consider.

[13]The reporting instructions for firms explicitly clarify that the firm is to report educational qualification as 'completed vocational degree' for adults who have either completed a dual firm-based apprenticeship or have obtained a recognized degree from a full-time vocational school (BA, 2008).

[14]Fitzenberger, Osikominu, and Völter (2005) suggest to use an imputation rule to ensure consistency of this variable over time. We follow this approach by measuring educational status as the highest value reported up to the age of interest.

[15]We discuss possible measurement error in this variable in Section 7.3.

To measure availability of apprenticeships, we make use of a unique data set, which annually records apprenticeship vacancies at a fine regional level, dividing Western Germany into 141 local labor markets.[16] This statistic contains the total number of apprenticeship vacancies that have been reported by firms to their local employment office with a request for assistance with placement of the vacancy. We normalize the vacancy data by an estimate of the number of young people who grow up in each district. We then assign each individual this measure of apprenticeship availability at age 16, in the relevant local labor market. — Means and standard deviations for our sample of the relevant variables are displayed in Table 1.

Table 1: Sample summary statistics

Variable	Mean	St. dev.
Apprenticeship training (years)	2.182	1.239
apprenticeship vacancies (at age 16)	0.622	0.254
unskilled vacancies (at age 16)	5.790	1.044
skilled vacancies (at age 16)	6.620	0.925
unskilled market wage (at age 16)	4.227	0.072
skilled market wage (at age 16)	4.372	0.069
unemployment rate (at age 16)	0.047	0.026
age (years)	24.507	1.114
German national (indicator)	0.879	0.326
Observations	242,014	

Note: Table reports means and standard deviations, reported for the sample of our outcome regression for probability of unemployment of at least 30 days, as reported in Table 5 below. Wages are log daily wages. For wages and general vacancies, the skilled group refers to those with either form of vocational degree (apprenticeship or full-time vocational schooling), and the unskilled group to those without vocational degree. See text for details.

4 Identification

This section has three parts. First, we describe a small open economy setting and incorporate educational choice between apprenticeship and vocational school. We investigate the effect of price shocks on educational choice and factor rewards to motivate an instrumental variable strategy. Second, we discuss how treatment effect identification is affected if one recognizes that individuals can choose between *three* different alternatives: apprenticeship training, vocational schools, or direct entry as unskilled worker. In this multinomial choice setting, we show that under specific circumstances, a univariate instrument continues to recover a well-defined treatment effect which is of interest. Third, we discuss the empirical implementation in this study.

[16] In the following, we refer to these interchangeably as *employment office districts* or *regions*.

4.1 A small open economy model with educational choice

We begin by describing each region as a small open economy, integrated through trade, and follow the standard assumptions of neoclassical trade models. Here, we summarize key properties of the model; a formal description is contained in the Appendix A.1.

To simplify the discussion, consider an economy in which two products are produced using two labor inputs (apprenticeship graduates and vocational school graduates). Technology is identical across regions and characterized by constant returns to scale, and positive and diminishing marginal productivities. Assume that products are freely traded across regions, while factors are mobile across sectors but immobile across regions. Product prices $(1, p)$ are determined at the world market.

With regards to the school leaver's educational choice, young people choose between apprenticeship training and vocational schooling alternatives. This choice is made by comparing alternative-specific utilities. These are made up of the respective present discounted value of future wages earned in the main labor market, a random individual-level shock which affects the utility of apprenticeship training, and a region-specific parameter which affects apprenticeship utility. This latter parameter may be interpreted, following Findlay and Kierzkowski (1983), as the local availability of an education-specific fixed factor. This specification leads to a region-specific educational decision rule which determines the number of apprentices as a function of the wage difference.[17] We follow standard assumptions of neoclassical trade models by assuming that one sector (say sector 1) is always characterized by a higher intensity of apprenticeship input than sector 2, and that equilibrium with incomplete specialization is possible.

In this setting, consider an increase in the price of good 2. This leads to an increase in the factor reward for the type of labor used intensively in that sector (i.e., the vocational school graduates). Sector 2 expands and sector 1 declines, whereby both sectors increase their factor intensity. In terms of educational choice, young people respond to this change in wages by moving into the non-apprenticeship track. Since the function which maps wage differences into apprentices is location-specific as described above, the response in the number of apprenticeship graduates differs across regions. Importantly, this model is characterized by factor-price equalization: For given product prices, factor rewards are identical across regions. Thus, this model describes a setting where a price shock translates into a differential response in terms of number of apprentices, but does not lead to a differential response in terms of factor

[17] Since higher wages will make this option more attractive and increases the number of individuals who choose this alternative, this specification satisfies normality as in McKenzie (1955).

rewards. Thus, this economic framework generates an exclusion restriction, which motivates an instrumental variable approach in comparing productivity across the two types of labor. Since industry price shocks and the location-specific characteristic (interpreted as availability of an education-specific factor) are not directly observed in this data, we implement this procedure by instead using the number of apprenticeship vacancies in each region. We assume that the economy adjusts quickly to changes in prices, so that the observed responses reflect movements between equilibria. – Although not explicitly modeled here, a straight-forward comparison of means would pick up selection effects arising from individual heterogeneity.

One important assumption of the model and the empirical strategy is that local variation is relevant for young people, in that they cannot adjust by moving to other regions. Regional mobility is generally thought to be low in Germany, and since apprenticeship wages are low, apprentices usually have to rely on living at home, so that factor immobility seems to be a sensible assumption for this group.

4.2 Identification with a univariate instrument in a multinomial choice setting

The interest of this paper is in comparing two alternative forms of obtaining a vocational qualification. It is natural to ask whether individuals might want to adjust to apprenticeship availability by entering the labor market as unskilled worker. This transforms the decision problem into a multinomial choice problem. In this section, we discuss how treatment effect identification is affected by this more general choice problem, and under what conditions the IV estimator recovers an alternative-specific parameter of interest; the corresponding empirical analysis is found in section 5.2 below.

Heckman and Vytlacil (2007) considers identification of treatment effects in an unordered multinomial choice model with a binary instrument. Define an alternative-specific treatment effect as difference in outcomes between choices j and m, $\Delta_{j,m} \equiv Y_j - Y_m$. Assuming that an instrument Z_j affects only the utility of choice alternative j, and is excluded both from the vector of potential outcomes as from the other choice-specific utilities, they show that the Wald estimand that arises from changing Z_j is equal to a weighted average of $\Delta_{j,m}$ across the other alternatives $m = 1...M$. In general, the IV estimator will not recover a comparison between two specific alternatives, but rather a *weighted average* across all possible alternatives. This reflects that in response to a change of the value of option j, 'movers' respond by changing into different alternatives, and the weights correspond to the probability of choosing a particular

option m as next-best alternative.[18]

In the context of this study, there is an important special case to this. If a change in the instrument Z_j induces all 'movers' to switch into the same second-best alternative, then the weighted average of alternative-specific causal effects collapses into a single alternative-specific causal effect. In this special case, the instrument Z_j (which modifies the value of taking option j) recovers $\Delta_{j,m}$ for a specific alternative m. Thus, there is a special case in which a univariate IV does recover one alternative-specific causal effect in a multinomial choice setting. Whether this special case applies in a particular application can be empirically verified: this reflects that we observe individuals' educational choices and can estimate how they respond to changes in the value of the instrument. We provide empirical evidence on this below in section 5.2. The evidence presented there clearly indicates that the IV estimator recovers the relative return between apprenticeship training and full-time vocational school alternatives. In our three-alternatives model, this is shown by documenting that the probability of working as unskilled does not respond to apprenticeship availability, which corresponds to a weight of 0 in the discussion above. This implies that the IV estimates presented in this paper do recover a well-defined treatment coefficient of interest even in this generalized multinomial setting.

A related concern might be that individuals respond to shocks in apprenticeship availability by going to college instead. The early tracking of pupils in the German education system allows us to abstract from the college-going decision: As described above, individuals are tracked at ages 10–12 into either a university-bound upper track or a lower- or medium-schooling track, so that the decision to go to university is already pre-determined through the tracking decision earlier on. Correspondingly, we eliminate all individuals from the university-bound upper track from our sample, and limit attention the lower- and medium level track.

4.3 Empirical implementation

We implement this approach in a linear empirical framework, which we now describe. Denote $Y_{i,cj,ta}$ as a labor market outcome of interest for individual i, who grew up in cohort c in region j, measured at age a in time period t. Our model for the outcome equation is

$$Y_{i,cj,ta} = \alpha_1 S_i + \alpha_{2j} + \alpha_{3c} + \alpha_{4t} + \alpha_{5a} + \alpha_6 X_i + \alpha_7 X_{cj} + \alpha_{8j} \cdot c + \epsilon_i \tag{1}$$

where S_i indicates apprenticeship training, and where we think of α_1 as being heterogeneous in the population. α_{2j}, α_{3c} correspond to region and cohort fixed effects, respectively, α_{4t}

[18] Conceptually, this is similar to the analysis of Angrist and Imbens (1995) for the variable treatment intensity case.

and α_{5a} to year and age indicators. X_i are individual characteristics, and X_{cj} to labor market characteristics at the time and region where the individual grew up; $\alpha_{8j} \cdot c$ denote region-specific trends. We instrument for S_i with apprenticeship availability, so that the corresponding first stage is

$$S_i = \gamma_1 Z_{cj} + \gamma_{2j} + \gamma_{3c} + \gamma_{4t} + \gamma_{5a} + \gamma_6 X_i + \gamma_7 X_{cj} + \gamma_{8j} \cdot c + u_i \tag{2}$$

where Z_{cj} denotes the availability of apprenticeships, corresponding to the cohort c in region j. As before, γ_{2j}, γ_{3c} correspond to region and cohort fixed effects, respectively, γ_{4t} and γ_{5a} to year and age indicators.[19] In all regressions presented, we account for permanent differences with fixed effects for regions, cohorts, and region-specific trends. We also control for labor market characteristics at age 16, which we discuss below in more detail.

Since we include district and cohort fixed effects, our estimates have the interpretation of diff-in-diff estimates, where differential developments in apprenticeship availability are used to identify the effect. In addition to that, our specification allows for linear region-specific time trends. This more general specification allows each district to follow a separate time trend.[20]

We now explain how we control for conditions in the local main labor market: first, we use a similar general vacancy measure, and control for the (log) number of general vacancies in the relevant (main) labor market (at age 16 as before), by skill level.[21] Second, we include local wages and unemployment rate for males (aged 25 to 40), in the relevant labor market at age 16. These additional controls allow for a broader description of the individual's choice problem.

5 The effect of apprenticeship vacancies on educational choice

In this section, we proceed as follows: We first document the effect of apprenticeship vacancies on educational choice, where we show that an increase in apprenticeship vacancies significantly increases the apprenticeship training undertaken. We then turn to clarifying the margin of adjustment, and document that variation in apprenticeship availability leads individuals to

[19]These last two sets of regressors capture year and age effects specific to the time when the outcome is measured. The problem of separately identifying cohort, age and time effect is well well known (Heckman and Robb, 1985). Year effects would not be separately identified if the cohort and age effects were fully interacted. Here we limit ourselves to the three additive sets of indicators, and follow the approach taken in Hall (1971) by excluding an additional dummy to avoid perfect collinearity. No attempt is made here to interpret the coefficients on these indicator variables, so that it is not of importance which of the indicator variables is eliminated (see Berndt and Griliches (1990)).

[20]We test for differential trends in our sample, by performing an F-test on the set of region-specific trends in the estimation equations. We find that the region-specific trends are significant at the 1% level both on the first stage and in the IV estimates. To perform this test, we cluster estimates by region-cohort cell.

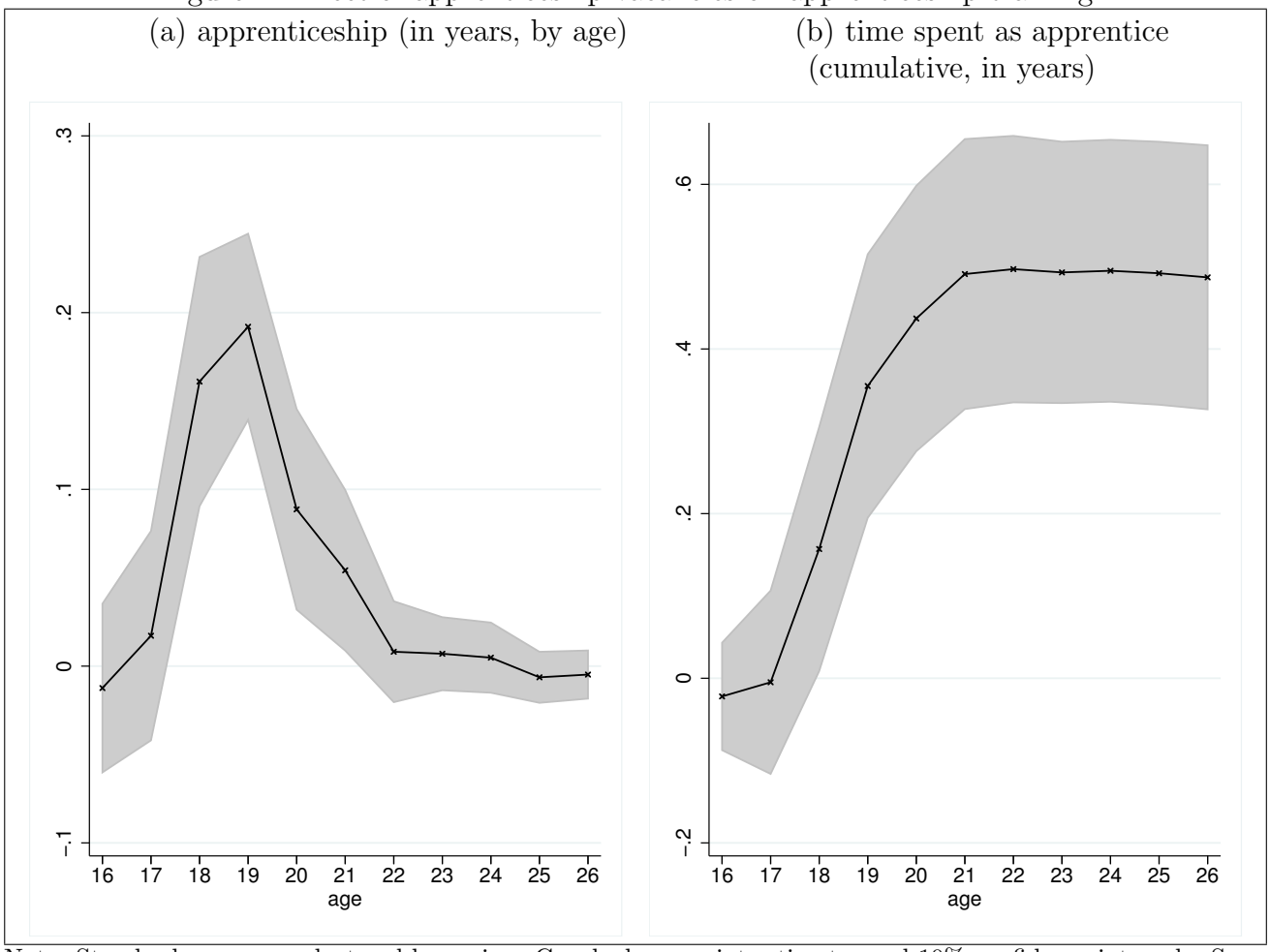
[21]Here, skill level refers to those with either form of vocational degree (skilled), compared to school-leavers who enter directly as regular employees (unskilled).

substitute between apprenticeship training and full-time vocational schools. We validate this with a falsification exercise. Finally, we present the first-stage regression that corresponds to our main results.

5.1 Vacancies and apprenticeship training

To start with, we consider how the amount of apprenticeship training undertaken at each age is affected by vacancies. For this purpose, we estimate equation (2), but take as outcome only apprenticeship training undertaken at a specific age.[22] The resulting coefficient (γ_1) measures the effect of apprenticeship vacancies on apprenticeship training at a particular age, measured as a fraction of the year. We obtain a separate coefficient for each age, from 16 to 26, and plot the resulting coefficients, each of which is estimated in a separate regression. The allows to show at which ages individual training decisions are affected. The results are shown in Figure 2 (a).

Figure 2: Effect of apprenticeship vacancies on apprenticeship training



Note: Standard errors are clustered by region. Graph shows point estimates and 10% confidence intervals. See the data section for the definition of the variables.

[22]Estimates are obtained using the same set of controls that we employ in the main results below.

The figure shows that apprenticeship availability has a pronounced and significant effect on the time spent as apprentice at ages 18 and 19, and the effect then declines to zero after that. This documents that – as expected – apprenticeship availability affects the educational choice of young adults after they leave school. We then repeat this exercise, but now look at the total years of apprenticeship training obtained up to a particular age. The dependent variable here varies from 0 for someone who has not (or not yet) entered the apprenticeship system, to 3.5 for someone who has done a full-length apprenticeship training. The resulting coefficients are shown in Figure 2 (b). At age 21, the effect of apprenticeship vacancies is fully realized, and the effect is flat afterwards. To get a sense of the magnitudes, recall that the instrument has a standard deviation of about 0.25; thus, a one standard deviation increase in the instrument moves expected apprenticeship training by about 0.125 years. As can be seen from this graph, apprenticeship vacancies at school-leaving age have a lasting effect on the individual's educational choice.

5.2 Clarifying the margin of adjustment

We interpret the availability of apprenticeship places as varying the utility specific to the apprenticeship option. In order to interpret the main results below, it is important to clarify where these marginal individuals, who have been affected by the vacancy variable, come from in a multinomial setting; this is the purpose of this section. Recall that we limit attention to non-college bound youth; then there are three potential avenues for a young adult who leaves school: the apprenticeship system, a full-time vocational school, or a direct entry into the labor market as unskilled worker. We now document the substitution behavior that is associated with an increase in apprenticeship vacancies. One hypothesis we investigate is that the marginal apprentice enters as unskilled worker when apprenticeship availability is low, and as apprentice when availability is high. We call this the *substitution for unskilled work* hypothesis. Alternatively, young people at the margin who do an apprenticeship when availability is good might be drawn from the pool of individuals who would otherwise obtain a vocational degree in a full-time vocational school, and we term this the *substitution for full-time vocational schooling* hypothesis.

To investigate this, we select all individuals aged 24, and group them into these three categories as follows. The *unskilled*, i.e. those who have neither form of vocational qualification, make up 21.5% in our sample. Second, individuals who have a vocational qualification based on a a full-length firm-based apprenticeship training, which we define as having a vocational

degree and at least 1.5 years of apprenticeship training.[23] This group (*apprentices*) account for 62.5% in our sample. The remaining individuals (*full-time vocational school*) make up 16% in our sample.[24] The proportions we obtain in our data fit well with estimates from other sources (see section 2.2 on page 8).

We now use this grouping to estimate a trivariate probit model, in which the main explanatory variable is apprenticeship vacancies. We include the same set of controls as outlined before.[25] The resulting marginal effects are reported in Table 2.

Table 2: Trivariate probit: Marginal effect of apprenticeship vacancies

category	variable	Marginal effects
group 1 unskilled	apprenticeship vacancies (at age 16)	-0.00164 [0.0342]
group 2 vocational school	apprenticeship vacancies (at age 16)	-0.124 [0.0386]***
group 3 apprenticeship	apprenticeship vacancies (at age 16)	0.126 [0.0396]***
	cohort fixed effects	Yes
	region fixed effects	Yes
	region trends	Yes
	labor market conditions at entry	Yes
	Observations	61358

Note: Standard errors reported in brackets, clustered by region. * indicates significance at 10%, ** indicates significance at 5%, *** indicates significance at 1% level. See text for details.

The effect of apprenticeship availability on the probability of being in the unskilled group is small and not statistically different from zero. Instead, the marginal effects on full-time vocational schooling and apprenticeship training are of similar magnitude and opposite signs, they are both statistically significant at the 1% level. This indicates that the apprenticeship vacancy variation induces individuals to move between vocational schooling and apprenticeship training.

Survey evidence supports this result. Troltsch et al. (1999) report evidence from a representative telephone survey of unskilled youth without any vocational qualification. Of those interviewed, the majority did not search for a training position, had an offer but rejected it,

[23]This can be thought of as a minimum requirement. Most apprenticeship programs have a full length of either three or three and a half years.

[24]Most of this third group have obtained their vocational degree entirely outside the apprenticeship system, and some are recorded with very short apprenticeship spells only.

[25]Since we restrict the sample to those aged 24 in this exercise, we do not need to account separately for age or year effects.

or started a training program but then dropped out. The fraction of individuals who indicate that they searched unsuccessfully is low (14%), suggesting that there is little room for apprenticeship vacancies to have any effect. Similarly, a number of characteristics strongly increase the probability of being in the unskilled group (e.g. dropping out of secondary school), which make it very difficult to enter either apprenticeship (because of firm hiring decision) or full-time vocational schools (because of school admission criteria).

In summary, the above estimates provide evidence in favor of the *substitution for full-time schooling hypothesis* and against the *substitution for unskilled work hypothesis*. We replicate this result in a linear regression framework, where we regress an indicator for being unskilled on the vacancy measure (and the set of controls) and find no effect, as reported in Table A.1 (in Appendix A.3).

For further evidence, we now turn to a falsification exercise, which exploits that our two substitution hypotheses imply different predictions about the age at which individuals are first seen in this employment data. We present these as IV estimates, where the regressor of interest is years of apprenticeship training. First, we look at the age at which an individual is first seen in the data, excluding apprenticeship spells. If individuals substitute between apprenticeship and *unskilled work*, we would expect a coefficient of 1: an additional year of apprenticeship training delays the first non-apprenticeship spell accordingly. Under the *substitution for full-time vocational schooling* hypothesis, on the other hand, we would expect a coefficient of 0, if the full-time vocational schools have roughly the same length as apprenticeship training. Estimates are found in Table 3.[26]

Column (1) reports the OLS results, which suggest that in a simple comparison of means, an additional year of apprenticeship delays the first non-apprenticeship spell. In column (2), we instrument using the vacancy data. The coefficient is now very close to zero and insignificant. This confirms that individuals at the margin switch between apprenticeship training and vocational schools.

In columns (3) and (4), we repeat this exercise for the age at which the individual is first ever seen in the data, *including* in apprenticeship training. Under the *unskilled* hypothesis, individuals are seen in the data at the same age as apprentices, so that the corresponding coefficient is 0. Under the *full-time vocational schooling* hypothesis, individuals are seen in the data a year earlier, because the firm registers the apprentice similar to its regular workers. The coefficient corresponding to this hypothesis is then -1. The resulting IV estimate is not

[26]The corresponding first stage is discussed in detail below.

Table 3: Falsification exercise: Age at first regular job

	Age first seen in data (*excluding* apprenticeship spells)		**Age first seen in data (*including* apprenticeship spells)**	
	OLS	IV	OLS	IV
	(1)	(2)	(3)	(4)
Apprenticeship training (years)	0.183	**-0.0703**	-0.787	**-0.969**
	[0.0153]***	**[0.313]**	[0.0159]***	**[0.278]*** **
German national (indicator)	-0.353	-0.0368	-0.375	-0.149
	[0.0404]***	[0.386]	[0.0387]***	[0.343]
cohort fixed effects	Yes	Yes	Yes	Yes
region fixed effects	Yes	Yes	Yes	Yes
region trends	Yes	Yes	Yes	Yes
age fixed effects	Yes	Yes	Yes	Yes
year fixed effects	Yes	Yes	Yes	Yes
Labor market controls at entry	Yes	Yes	Yes	Yes
Observations	241585	241585	242014	242014
First stage F-statistic		24.96		25.55
First stage p-value		0.00000172		0.00000133
Mean (dependent variable)	19.62	19.62	17.50	17.50
St. dev. (dependent variable)	1.796	1.796	1.928	1.928
Hypothesis test: Substitution for unskilled work				
Corresponding parameter value		1		0
F-statistic		11.68		12.16
p-value		0.000827		0.000651
Hypothesis test: Substitution for full-time vocational schooling				
Corresponding parameter value		0		-1
F-statistic		0.0504		0.0121
p-value		0.823		0.913

Note: Standard errors reported in brackets, clustered by region. * indicates significance at 10%, ** indicates significance at 5%, *** indicates significance at 1% level. See text for details. Hypothesis test at the bottom of the table refers to the coefficient of the variable 'years of apprenticeship training'.

statistically different from -1, as indicated by our test at the bottom of the table, while we reject a coefficient of 0 at the 1% level.

We conclude that the estimates which we present in the following should be interpreted as being the treatment effect of the individual who switches from vocational full-time schooling to firm-based apprenticeship, depending on the local availability of apprenticeships. Doing so we follow the work of Imbens and Angrist (1994) on the Local Average Treatment (LATE) parameter, an interpretation that requires a monotonicity assumption on how individuals react to changes in the instrument.

The estimates above do not only clarify the interpretation of our estimates provided below; they also convey an important substantive point relating to economic policy. They indicate that when full-time vocational schooling exists as alternative, measures which increase supply

of apprenticeship vacancies are likely to draw individuals from these full-time vocational schools rather than individuals who would have entered the labor market directly as unskilled workers. In that sense, the results suggest that policies which expand availability of apprenticeships are effective in increasing the take-up of firm-based apprenticeship training, but they are not necessarily effective in reducing the number of unskilled workers, when vocational schooling exists as alternative.

5.3 First stage results

Table 4 presents the first stage results which correspond to our main outcome equation.[27] The dependent variable of interest is years of apprenticeship training obtained. As sample

Table 4: First stage

	Apprenticeship training (years)		
	OLS	OLS	OLS
	(1)	(2)	(3)
apprenticeship vacancies (at age 16)	0.505	0.490	0.492
	[0.0970]***	[0.0981]***	[0.0974]***
unskilled market wage (at age 16)		-0.174	-0.166
		[0.240]	[0.239]
skilled market wage (at age 16)		0.248	0.235
		[0.493]	[0.492]
unemployment rate (at age 16)		0.438	0.435
		[0.452]	[0.456]
unskilled vacancies (at age 16)			0.0301
			[0.0185]
skilled vacancies (at age 16)			0.000405
			[0.0305]
German national (indicator)	1.243	1.243	1.243
	[0.0283]***	[0.0283]***	[0.0283]***
cohort fixed effects	Yes	Yes	Yes
region fixed effects	Yes	Yes	Yes
region trends	Yes	Yes	Yes
age fixed effects	Yes	Yes	Yes
year fixed effects	Yes	Yes	Yes
Observations	242014	242014	242014
First stage F-statistic	27.09	24.94	25.55
First stage p-value	0.0000	0.0000	0.0000
Mean (dependent variable)	2.182	2.182	2.182
St. dev. (dependent variable)	1.239	1.239	1.239
Minimum (dependent variable)	0	0	0
Maximum (dependent variable)	3.500	3.500	3.500

Note: Standard errors reported in brackets, clustered by region. * indicates significance at 10%, ** indicates significance at 5%, *** indicates significance at 1% level. See text for details.

we select individuals aged 23 through 26. Each column in Table 4 corresponds to a different

[27]Between different outcomes, the available sample differs slightly. We present the first stage here for one of our main outcomes, unemployment for at least 30 calendar days, as reported in Table 5 on page 22 below. In the IV results below, we report the corresponding F-statistic along with the estimates.

set of control variables. Column (1) only includes an indicator of German nationality. The variable of interest measures apprenticeship vacancies. The corresponding coefficient for the apprenticeship degree indicator is 0.505, and it is significant at the one percent level. Keeping in mind that the standard deviation of this variable is about 0.25, a one standard deviation change in apprenticeship vacancies increases average apprenticeship training by about 0.125 years.

In columns (2) and (3), we add further controls for local labor market conditions at age 16, allowing us to investigate whether the first stage coefficient of interest is sensitive to a slightly extended specification of the educational choice stage. These variables vary at the same level as our instrument. Column (2) adds average local wages and unemployment rates, computed for males aged 25 to 40.[28] The coefficient on apprenticeship vacancies goes down somewhat, but the change is small and does not affect the significance of the coefficient at all. In column (3) we control for the number of all open vacancies (in logs) at age 16 in the main labor market in the relevant region, separately by required skill level.[29] Columns (1) to (3) demonstrate that shocks in apprenticeship availability translate into differences in educational attainment as measured by apprenticeship training, and further that this effect is statistically strong and robust to an extended specification of the educational decision problem.

An important concern in IV estimation is the problem of weak instruments (Bound, Jaeger, and Baker, 1995; Staiger and Stock, 1997; Stock, Wright, and Yogo, 2002). One way to assess this is to consider the F-statistic from the first stage. As indicated in the bottom of table, the F-statistics from the instrument here are above 25, respectively, and well above the rule of thumb of an F-statistic of 10. This suggests that weak instruments should not be a concern in this application.

6 Effect of training form on labor market outcomes

6.1 Unemployment and wages

As outcomes, we focus on unemployment and wages. We define an indicator for unemployment of at least 30 days during the calendar year. Wages refer to log average daily wage in full-time employment during the calendar year. We select all young adults aged 23 to 26, and pool annual observations for efficiency. All standard errors are clustered at the region level, allowing for

[28] Average wages are included separately for skilled versus unskilled workers, referring to whether the individual has completed either form of vocational training, or no vocational training.

[29] Here, skill level refers to whether a position requires some form of completed vocational qualification, or not.

arbitrary within-cluster dependence in the error term, including serial correlation. Estimates are reported in Table 5.

Table 5: Main outcomes

	Indicator: Unemployed at least 30 days		**Log average daily wages**	
	OLS	IV	OLS	IV
	(1)	(2)	(3)	(4)
Apprenticeship training (years)	-0.0355	-0.105	0.0309	0.0289
	[0.00133]***	[0.0457]**	[0.00133]***	[0.0501]
unskilled market wage (at age 16)	0.0183	0.00851	-0.0738	-0.0743
	[0.0584]	[0.0634]	[0.0521]	[0.0520]
skilled market wage (at age 16)	-0.0474	-0.0260	-0.0822	-0.0817
	[0.144]	[0.152]	[0.112]	[0.112]
unemployment rate (at age 16)	-0.384	-0.317	-0.111	-0.109
	[0.117]***	[0.115]***	[0.102]	[0.108]
unskilled vacancies (at age 16)	0.00679	0.00860	0.00373	0.00377
	[0.00446]	[0.00498]*	[0.00441]	[0.00454]
skilled vacancies (at age 16)	-0.00124	-0.000175	-0.00185	-0.00181
	[0.00638]	[0.00647]	[0.00777]	[0.00782]
German national (indicator)	-0.0127	0.0737	0.00570	0.00822
	[0.00470]***	[0.0557]	[0.00460]	[0.0635]
cohort fixed effects	Yes	Yes	Yes	Yes
region fixed effects	Yes	Yes	Yes	Yes
region trends	Yes	Yes	Yes	Yes
age fixed effects	Yes	Yes	Yes	Yes
year fixed effects	Yes	Yes	Yes	Yes
Observations	242014	242014	218438	218438
First stage F-statistic		25.55		16.43
First stage p-value		0.00000133		0.0000835
Mean (dependent variable)	0.149	0.149	4.203	4.203
St. dev. (dependent variable)	0.356	0.356	0.320	0.320

Note: Standard errors reported in brackets, clustered by region. * indicates significance at 10%, ** indicates significance at 5%, *** indicates significance at 1% level. See text for details.

Column (1) presents the OLS estimate for the unemployment outcome. According to this estimate, an additional year of apprenticeship training reduces the probability of unemployment by 0.0355 percentage points. Column (2) instruments for apprenticeship. The effect goes up substantially in magnitude, and the resulting coefficient is 0.105. Although precision decreases, the effect remains significant at the 5% level. This evidence suggests that in this age range, former apprenticeship graduates have a lower probability of being unemployed.

In a constant coefficient framework, the difference between OLS and IV estimates is informative about the direction of selection bias, which here would suggest negative selection.[30] In

[30]A priori, the direction of selection bias is unclear. On the one hand, firms select positively from the applicants. On the other hand, comparing vocational full-time schools and apprenticeship training, it is possible that more academically inclined individuals have a preference for schools, and that school are rigorous in enforcing admission standards. Bonnal, Mendes, and Sofer (2002) find evidence of negative selection into apprenticeship for France. Plug and Groot (1998) find no evidence of self-selection for a sample of Dutch young

a heterogeneous treatment effect framework, the IV estimate reflects the treatment effect of the marginally affected subgroup (who switch between apprenticeship training and full-time vocational schools), indicating that this group is characterized by a higher treatment effect.

We now turn to estimating the effect on productivity as measured by wages. The main IV estimate is reported in column (4) of Table 5. Interestingly, the OLS and IV coefficients are very similar at about 3 per cent. Once we instrument, the effect on wages is not statistically different from zero. This suggests that the two alternative forms of training lead to similar levels of productivity, but it is important to keep in mind that the standard error of this estimate is relatively large.

To the young trainee, one benefit of apprenticeship training may be the access to the firm's internal labor market, as argued for example by Soskice (1994). Our estimates may, at least in partly, reflect that a fraction of the apprenticeship graduates may stay on in their training firm, while the vocational school graduates are more likely to go through search unemployment at the end of their training, and then over time catch up with apprenticeship graduates. Our data allows us to investigate this directly by splitting up the sample by age, and estimate separately for each age. These results are reported in Table 6. Columns (1) through (4) show the OLS effects by age, which basically remain constant at 0.035. Columns (5) to (8) show the IV results. Here, we find a pronounced pattern over time: The effect declines rapidly with age. At age 26, it is no longer significant. The IV result suggests that the beneficial effect of lower unemployment probability is not permanent, but transitory.[31] This is consistent with the interpretation that the apprenticeship training smooths the initial transition into the main labor market, but that the vocational school graduates then catch up over time.

6.2 Effect on mobility

We also investigate year-on-year mobility as measured by changing occupation or industry. Mobility measures inform us about transferability of skills, especially given that one may be concerned that apprenticeship training is very specific and leads to lock-in effects. A number of studies document an unexpectedly high fraction of former apprentices who work in occupations different from the one they trained in (see e.g. Werwatz (2002)). This has been interpreted as indicating that the training provides more general skills, or acts as a signal for general worker quality (Heckman, 1993). Our set-up here allows us to compare mobility rates between different forms of vocational training, and we look at occupational and industry mobility. The

adults.

[31] Note that the mean of the dependent variable remains very similar across the age range.

Table 6: Effect on unemployment by age

	Unemployed for at least 30 days at age\ldots				**Unemployed for at least 30 days at age\ldots**			
	23	**24**	**25**	**26**	**23**	**24**	**25**	**26**
	OLS	OLS	OLS	OLS	IV	IV	IV	IV
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
apprenticeship training (years)	-0.0354	-0.0344	-0.0363	-0.0359	**-0.148**	**-0.134**	**-0.0987**	**-0.0573**
	[0.00167]***	[0.00153]***	[0.00167]***	[0.00163]***	**[0.0716]****	**[0.0683]***	**[0.0519]***	**[0.0566]**
cohort fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
region fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
region trends	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
age fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Labor market controls at entry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Personal characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	59315	61358	60785	60556	59315	61358	60785	60556
First stage F-statistic					15.49	20.43	26.67	35.46
First stage p-value					0.000	0.000	0.000	0.000
Mean (dependent variable)	0.158	0.151	0.144	0.142	0.158	0.151	0.144	0.142
St. dev. (dependent variable)	0.365	0.358	0.351	0.349	0.365	0.358	0.351	0.349

Note: Standard errors reported in brackets, clustered by region. * indicates significance at 10%, ** indicates significance at 5%, *** indicates significance at 1% level. See text for details.

rate of year-on-year mobility in both dimensions is high at around 15 percent. Estimates are reported in Table 7. The OLS result suggests that apprenticeship training has a negative effect on mobility. Once we instrument, the coefficient turns positive, but our results are imprecisely estimated; we find no significant evidence of differential mobility behavior between the two groups.

Table 7: Mobility

	change in occupation		**change in industry**	
	OLS	IV	OLS	IV
	(1)	(2)	(3)	(4)
apprenticeship training (years)	-0.0178	0.0573	-0.0118	0.0152
	[0.000953]***	[0.0637]	[0.000980]***	[0.0573]
unskilled market wage (at age 16)	-0.0304	-0.00302	0.0553	0.0658
	[0.0442]	[0.0534]	[0.0470]	[0.0522]
skilled market wage (at age 16)	-0.0743	-0.0888	-0.0468	-0.0538
	[0.108]	[0.115]	[0.104]	[0.105]
unemployment rate (at age 16)	-0.140	-0.227	-0.0495	-0.0774
	[0.101]	[0.138]	[0.0941]	[0.113]
unskilled vacancies (at age 16)	0.00332	0.000984	0.00789	0.00703
	[0.00339]	[0.00406]	[0.00329]**	[0.00409]*
skilled vacancies (at age 16)	-0.00382	-0.00505	-0.00847	-0.00895
	[0.00583]	[0.00609]	[0.00606]	[0.00592]
German national (indicator)	-0.0262	-0.119	-0.0125	-0.0456
	[0.00387]***	[0.0786]	[0.00408]***	[0.0702]
cohort fixed effects	Yes	Yes	Yes	Yes
region fixed effects	Yes	Yes	Yes	Yes
region trends	Yes	Yes	Yes	Yes
age fixed effects	Yes	Yes	Yes	Yes
year fixed effects	Yes	Yes	Yes	Yes
Observations	183245	183245	183085	183085
First stage F-statistic		9.104		7.960
First stage p-value		0.00303		0.00548
Mean (dependent variable)	0.144	0.144	0.150	0.150
St. dev. (dependent variable)	0.351	0.351	0.357	0.357

Note: Standard errors reported in brackets, clustered by region. * indicates significance at 10%, ** indicates significance at 5%, *** indicates significance at 1% level. See text for details.

6.3 Responsiveness to negative shocks

One of the key questions in the debate on how apprenticeship training compares to other forms of training relates to the individual's ability to adjust to negative shocks. For example, Heckman, Roselius, and Smith (1993) suggest that narrow technical training may reduce options later in life by introducing rigidities; an overly tight link to a specific task or firm may result in constraints (Witte and Kalleberg, 1995).[32] One particular concern is that the benefit from

[32]Although long-run career constraints are clearly of interest, the individuals in our sample are still too young to be informative about that. At the same time, it is likely that the role of the employment experience in the

apprenticeship training may be very specific to the firm, and not sufficiently transferable if the firm-worker match is hit by a negative shock. In this section, we assess this empirically by studying the responsiveness of the young person to a job destruction shock. To do this, we follow the literature on firm closures as a negative shock. This approach has been widely used as a source of exogenous job destruction (Jacobson, LaLonde, and Sullivan, 1993; Oreopoulos, Page, and Stevens, 2008; Sullivan and von Wachter, 2007). We implement this as follows: For each worker, our data contains information on firm closures by recording the last year in which employees were recorded under this firm identifier. This allows us to identify firm closures. We define workers to be *at risk* if their employing firm ceases to exist in the same or the following year. We then consider the probability of being unemployed in period t, and investigate the effect of having been at risk in period $t-1$. Since we are concerned with the differential effect between forms of training, our coefficient of particular interest is the interaction between apprenticeship training and the indicator for being at risk. We control for the at-risk indicator.[33] Our specification now has two endogenous variables (apprenticeship training, and the interaction between training and being at risk in the previous period), and we instrument for these variables with apprenticeship availability, and availability interacted with the at-risk indicator. Results are found in Table 8, where we present results for being unemployed for at least 30 days, at least 45 days, and for log wages.

Columns (1) and (2) report the first stages. As indicated in the F-statistics, both first stages are statistically significant with a low p-value. Column (3) reports the IV estimate for the indicator of being unemployed for at least 30 days. The first row shows the effect of apprenticeship training on unemployment. This essentially replicates the baseline result we reported above, that apprenticeship training reduces the probability of being unemployed. The interaction in the second row shows how the effect differs when the individual is hit by a negative shock. Although this coefficient is not individually significant, it indicates that the adverse effect of firm closures is stronger for (former) apprentices. We repeat this exercise for the indicator of being unemployed for at least 45 days, and find essentially the same pattern, except that here the interaction term is individually significant at the 10% level. Column (5) considers log wages; the coefficient on the interaction is negative but insignificant.

As reported at the bottom of the table, the coefficients are jointly significant for the unem-

main labor market increases relative to initial vocational training (Witte and Kalleberg, 1995), so that our age group should be of particular interest.

[33]Thus, we follow the firm closures literature in maintaining the assumption that the firm closure is a random event. In this context, a natural way of examining this is by regressing the at-risk indicator on apprenticeship vacancies at age 16. We find that apprenticeship vacancies do not have a significant effect on the probability of being at-risk, consistent with the interpretation of firm closures as a random shock.

Table 8: Responsiveness to negative shock (firm closure)

			Unemployed at least 30 days	Unemployed at least 45 days	Log average daily wages
	First (i)	First (ii)	IV	IV	IV
	(1)	(2)	(3)	(4)	(5)
apprenticeship training (years)			-0.132	-0.103	0.0326
			[0.0611]**	[0.0533]*	[0.0568]
apprenticeship * closure indicator			0.165	0.169	-0.114
			[0.105]	[0.0958]*	[0.0887]
apprenticeship vacancies (at age 16)	0.379	0.0161			
	[0.125]***	[0.0133]			
apprent. vacancies * closure indicator	-0.131	0.218			
	[0.0759]*	[0.0898]**			
closure indicator	-0.0774	1.895	-0.205	-0.228	0.119
	[0.0533]	[0.0595]***	[0.211]	[0.194]	[0.180]
cohort fixed effects	Yes	Yes	Yes	Yes	Yes
region fixed effects	Yes	Yes	Yes	Yes	Yes
region trends	Yes	Yes	Yes	Yes	Yes
age fixed effects	Yes	Yes	Yes	Yes	Yes
year fixed effects	Yes	Yes	Yes	Yes	Yes
Labor market controls at entry	Yes	Yes	Yes	Yes	Yes
Personal characteristics	Yes	Yes	Yes	Yes	Yes
Observations	176492	176492	176492	176492	170140
First stage F-statistic	6.049	4.988			
First stage p-value	0.00302	0.00808			
Mean (dependent variable)	2.196	0.0652	0.0977	0.0849	4.235
St. dev. (dependent variable)	1.213	0.428	0.297	0.279	0.307
Hypothesis test: Joint significance					
F-statistic			4.259	3.676	1.149
p-value			0.0160	0.0278	0.320
Hypothesis test: add to zero					
F-statistic			0.0650	0.339	0.518
p-value			0.799	0.561	0.473

Note: Standard errors reported in brackets, clustered by region. * indicates significance at 10%, ** indicates significance at 5%, *** indicates significance at 1% level. See text for details.

ployment outcome, indicating that the form of training matters for the pattern of unemployment in this context. Interestingly, the two coefficients are of similar magnitude, so that the coefficient on the at-risk interaction offsets the beneficial effect of apprenticeship training. We formalize this by testing whether the two coefficients sum to 0. As shown at the bottom of the table, this hypothesis cannot be rejected at any reasonable level of significance. This implies that apprenticeship reduces the probability of being unemployed, but this benefit is lost if the worker's firm closes down. After the worker-firm match is hit by destruction, the job finding rate is no different between the two forms of vocational training.

7 Robustness Checks

In this section, we present a number of checks to investigate the sensitivity of the results presented in Table 5.

7.1 Grouped data

The importance of accounting for dependence in the data is well understood at least since Moulton (1990), and all standard errors in this paper are adjusted by clustering on the region level. An alternative way of recognizing that the identifying variation is on region-cohort level is to take averages in region-cohort cells, and to repeat the analysis on this aggregated data using averages for all variables which vary within region-cohort cells. Here, we present the corresponding estimates. Table 9 shows the estimates for the unemployment and the wage outcome. As expected, the estimates are very similar to the main estimates reported above.

Table 9: Sensitivity: Grouped data

	Indicator: unemployed at least 30 days			**Average log daily wages**		
	(1)	(2)	(3)	(4)	(5)	(6)
	First stage	OLS	IV	First stage	OLS	IV
apprenticeship training (years)		-0.0318	-0.0741		0.0359	0.0217
		[0.00711]***	[0.0437]*		[0.00654]***	[0.0534]
apprenticeship vacancies (at age 16)	0.494			0.447		
	[0.107]***			[0.121]***		
unskilled market wage (at age 16)	-0.196	0.0146	0.0130	-0.271	-0.0819	-0.0821
	[0.263]	[0.0642]	[0.0674]	[0.268]	[0.0564]	[0.0569]
skilled market wage (at age 16)	0.203	-0.0548	-0.0331	0.190	-0.0855	-0.0807
	[0.543]	[0.157]	[0.162]	[0.536]	[0.124]	[0.122]
unemployment rate (at age 16)	0.412	-0.386	-0.335	0.437	-0.121	-0.107
	[0.501]	[0.127]***	[0.125]***	[0.531]	[0.113]	[0.120]
unskilled vacancies (at age 16)	0.0302	0.00647	0.00760	0.0257	0.00392	0.00421
	[0.0204]	[0.00494]	[0.00523]	[0.0213]	[0.00482]	[0.00499]
skilled vacancies (at age 16)	0.00103	-0.00128	-0.000797	0.00386	-0.00174	-0.00163
	[0.0336]	[0.00709]	[0.00712]	[0.0345]	[0.00852]	[0.00855]
German national (indicator)	1.242	-0.0483	0.00717	1.253	0.0414	0.0601
	[0.120]***	[0.0285]*	[0.0602]	[0.120]***	[0.0236]*	[0.0707]
cohort fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
region fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
region trends	Yes	Yes	Yes	Yes	Yes	Yes
calender year (linear)	Yes	Yes	Yes	Yes	Yes	Yes
age (linear)	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1689	1689	1689	1689	1689	1689
First stage F-statistic			21.48			13.67
First stage p-value			0.000			0.000
Mean (dependent variable)	2.182	0.149	0.149	2.188	4.203	4.203
St. dev. (dependent variable)	0.269	0.0698	0.0698	0.282	0.0649	0.0649

Note: Standard errors are clustered on the region level. Data is collapsed into region-cohort cell means. In this specification, age and time fixed effects are replaced by cell-specific mean of age and time. Observations are weighted by cell size to account for the varying precision in estimating the corresponding means.

7.2 Controlling for occupation-specific fixed effects

If the distribution across occupations differs between the two tracks, one might be worried that our results may partly pick up systematic differences between occupations. We therefore investigate how the results change if one explicitly accounts for occupational fixed effects. The results are found in in Panel B of Table 10.[34] They indicate that controlling for occupational fixed effects reduces the magnitude of the estimates for OLS and IV estimates, although the level of significance of the estimates is unchanged. One interesting difference is that for the log daily wages outcome, the IV coefficient is now very close to zero. This reinforces our earlier conclusion that there are no significant productivity differences between the two groups.

7.3 Measurement error in years of apprenticeship training

In this section we investigate one possible source of measurement error in the apprenticeship years data, which concerns the exact date of the transition from apprenticeship training into full-time employment for some of the years in our data: Firms are only required to report the exact end date of an apprenticeship training from 1992 on (Schwerdt and Bender, 2003). Before that, apprentices who stay on in their training firm after apprenticeship training, and become regular skilled employees in the same firm without any kind of interruption, may be reported as full-time employees for the entire calendar year in which the transition occurs, although in fact they are apprentices in the first part of the year, and regular employees only after the exam. In these cases, we will undercount the number of days spent in apprenticeship training, because we do not observe the days in apprenticeship training in the last year of training. This may introduce some measurement error into the apprenticeship duration data. This is a very limited form of mis-measurement: It does not affect whether we ever see a young adult as apprentice, but it only affects the last calendar year of apprenticeship training. Thus, the undercount consists of either one or six to seven months, depending on the examination date, relative to a full apprenticeship duration of typically three (or three and a half) years.

As a sensitivity check, we use an imputed version of the apprenticeship duration variable. All affected cases share the property that they are seen in the data as apprentice until December 31, and are then reported as skilled employees from January 1 in the same company. Since the apprenticeship terminates with the final exam, which is typically towards the end of January (end of first semester) or during June or July (end of second semester), this transition at the end of the calendar year is a strong signal for this kind of misclassification. We flag these

[34] Panel A replicates the base case results for easy reference.

Table 10: Sensitivity analysis

	Indicator: Unemployed at least 30 days		Average log daily wages	
	OLS	IV	OLS	IV
	(1)	(2)	(3)	(4)
Panel A: Base case results				
Apprenticeship training (years)	-0.0355	-0.105	0.0309	0.0289
	[0.00133]***	[0.0457]**	[0.00133]***	[0.0501]
Observations	242014	242014	218438	218438
First stage F-statistic		25.55		16.43
First stage p-value		0.000		0.000
Panel B: Controlling for occupational fixed effects (two-digit classification)				
Apprenticeship training (years)	-0.0287	-0.0947	0.0273	0.00515
	[0.00132]***	[0.0471]**	[0.00105]***	[0.0444]
Observations	239662	239662	217378	217378
First stage F-statistic		24.94		16.28
First stage p-value		0.000		0.000
Panel C: Measurement error corrected				
Apprenticeship training	-0.0373	-0.111	0.0331	0.0307
(years, corrected)	[0.00136]***	[0.0490]**	[0.00132]***	[0.0533]
Observations	242014	242014	218438	218438
First stage F-statistic		23.30		14.64
First stage p-value		0.000		0.000
Panel D: Excluding inner-German border regions				
Apprenticeship training (years)	-0.0346	-0.118	0.0312	0.0360
	[0.00137]***	[0.0456]**	[0.00139]***	[0.0544]
Observations	223315	223315	201753	201753
First stage F-statistic		28.45		18.19
First stage p-value		0.000		0.000
Panel E: Using log number of apprenticeship places as instrument				
Apprenticeship training (years)	-0.0355	-0.093	0.0309	0.006
	[0.00133]***	[0.047]*	[0.00133]***	[0.056]
Observations	242014	242014	218438	218438
First stage F-statistic		18.19		12.49
First stage p-value		0.000		0.001

Each panel in this table corresponds to a separate sensitivity analysis. Panel A replicates the base case results for easy reference. Panel B additionally controls for occupational fixed effects on a two-digit level. Panel C uses as dependent variable the measurement-error corrected version of apprenticeship training. Panel D replicates the results omitting all areas at the inner-German border. Panel E omits normalization by cohort size. Note: Standard errors reported in brackets, clustered by region. * indicates significance at 10%, ** indicates significance at 5%, *** indicates significance at 1% level. See text for details.

cases, and then increase the duration of apprenticeship training by four months, which is the mean number of months expected in the last year of training between the two exam dates. We then re-run our main specification on this imputed variable, which corrects for the undercount. Results are found in Panel C of Table 10.

The estimated coefficients are almost identical for both the wage and the unemployment outcome. The F-statistic is marginally lower, which reduces the precision of the main estimates somewhat, but both the size of the main coefficients and the level of significance is unchanged when we use this imputed version.

7.4 Further specification checks

The inner-German border opened up in 1989, within the observation window of this study. It is known that the inner-German border regions experienced differential development from other parts of the country (Buettner and Rincke, 2007). In particular, workers from the eastern part of Germany commuted to West German border areas for better employment prospects in the face of strong economic differentials between east and west. To investigate whether this may have had any effect on our results, we exclude all districts in our sample at the inner-German border. This reduces the number of districts from 141 to 127. The results are shown in Panel D of Table 10. The coefficients are again virtually unchanged, which strongly suggests that our results are not affected by any differential behavior in the border regions.

While a normalization seems to be an appropriate way to measure the relevant availability of apprenticeships, a natural question of interest would be to isolate the role of the vacancy availability from the cohort size. To answer that, we re-estimate our main results, but take as instrument the log number of reported vacancies. We report these estimates in Panel E of Table 10. Without the normalization, the F-statistic is lower, but the IV coefficient on apprenticeship training in the unemployment equation is of a similar magnitude and the estimate has a p-value of 0.051. The estimate in the wage equation is again very close to 0. This indicates that while the normalization is useful in measuring relative availability, the main source of variation is the number of apprenticeship places.

7.5 Functional form

The empirical specification outlined in equations (1) and (2) imposes a specific functional form on the model. In particular, it imposes that our key variable for apprenticeship, Z_{cj}, enters linearly in the conditional mean of the first stage and the outcome equation. The objective

of this section is to semiparametrically investigate whether this functional form is appropriate. For that purpose, we estimate the partially linear model of Robinson (1988), which allows the effect of apprenticeship availability to be completely unrestricted:

$$S_i = f(Z_{cj}) + \alpha_{2j} + \alpha_{3c} + \alpha_{4t} + \alpha_{5a} + \alpha_6 X_i + \alpha_7 X_{cj} + \alpha_{8j} \cdot c + \epsilon_i \tag{3}$$

and similarly for the reduced form equation. Here, $f(\cdot)$ can be an arbitrary smooth function, which we estimate non-parametrically following the two-step approach from Robinson (1988).

For this exercise, we take the sample of our regression for the outcome unemployment of at least 30 days in the calendar year, for the sample of 24-year olds. We employ a biweight Kernel function and set the bandwidth to $h_z = 0.10$ in this exercise. In a preliminary experiment, we cross-validated the bandwidth and obtained values of at least $h_z = 0.14$, so we substantially undersmooth relative to that, which should help to bring out any non-linearities.[35] The result of this procedure – the nonparametric estimate of $f(\cdot)$ – can be seen in Figure 3, together with an estimate of the density of Z for reference. We superimpose the prediction from the linear model for comparison, along with the corresponding 10% confidence interval.[36]

As can be seen from the figure, the nonparametric estimate and the linear prediction are very close together, and even in areas of low density the differences are modest. We conclude that the assumption of linearity appears to be appropriate in this application.

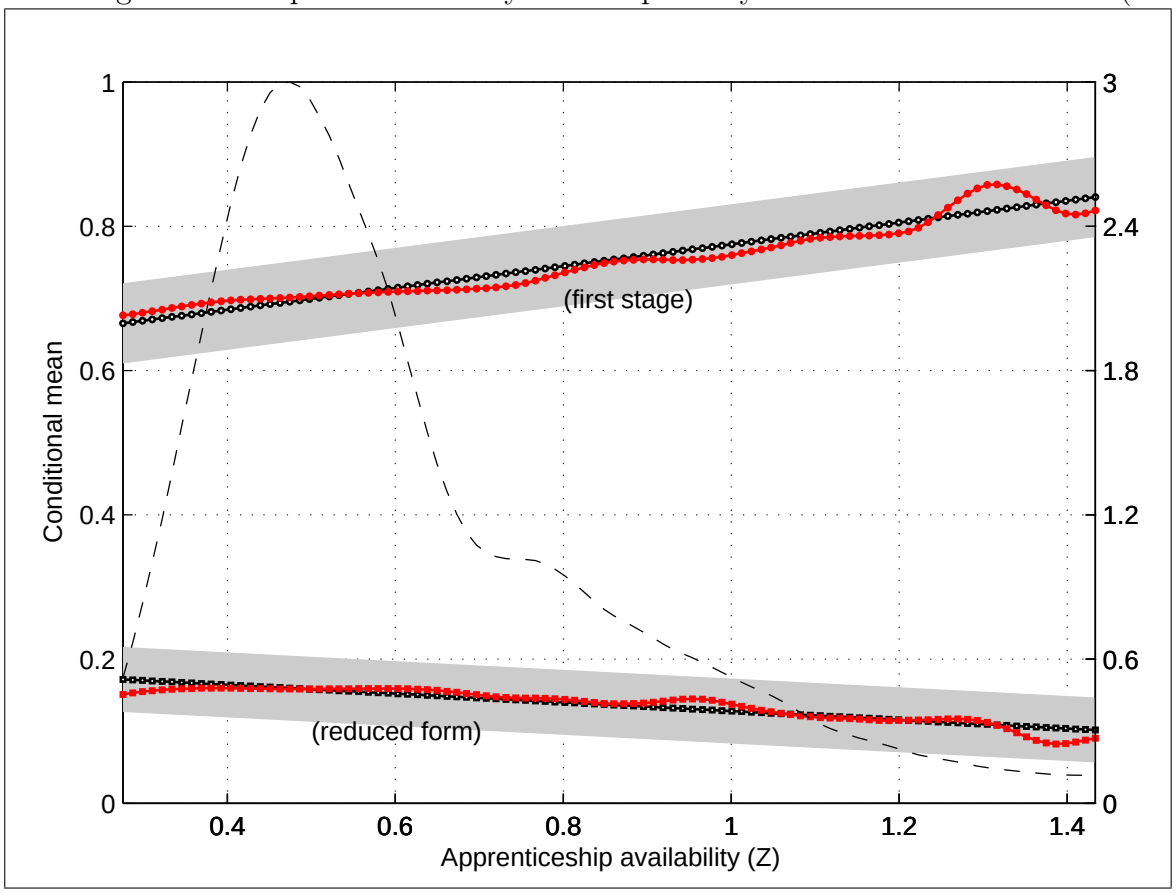
8 Conclusion

The objective of this paper is to study the relative returns to apprenticeship training relative to vocational schooling. This identifies a parameter which is of substantial interest to policy-makers, who are faced with the decision of how to design vocational education. The diversity of vocational schooling schemes around the world may be seen as evidence that there is no consensus on how these schemes compare. An empirical investigation needs to take account of potentially strong selection effects. We exploit that non-college bound young adults are subject to fluctuation in the availability of apprenticeships. We document that this affects their schooling choice, and leads them to substitute between apprenticeship training and vocational schooling. We use this exposure to estimate the differential return in a rigorous empirical

[35]Cross-validation suggests a bandwidth of $h_z = 0.14$ and $h_z = 0.18$ for the first stage and the reduced form, respectively. To reduce computational burden, cross-validation is done in univariate regressions. In the cross-validation, we trim the highest and lowest one percentile in the Z dimension to reduce the effect of outlier values in the cross-validation objective function. In the leave-one-out prediction, we account for the dependence in the data by excluding all points with the same value of Z.

[36]The partially linear model does not separately identify the intercept. We shift the estimates to match the predicted means.

Figure 3: Semiparametric analysis: The partially linear model of Robinson (1988)



Note: Graph shows estimates over the first to the 99th percentile range in the Z dimension (apprenticeship availability). Density estimate is rescaled. See text for details.

framework, which accounts for permanent region and cohort effects, and allows for region-specific time trends.

Our findings suggest that the skills young people obtain are in fact similar between vocational schooling and apprenticeship training, as measured by wages at ages 23 to 26. That suggests that both schemes have similar productivity effects on participants; the benefits and drawbacks of either form of instruction seem to be balancing out in terms of effects on productivity. That is an important finding in the context of the debate on the relative merits of these alternatives.

At the same time, we find substantial and significant differences in the probability of unemployment. Importantly though, this effect shows a strong age profile. We trace this effect across the age of the young adult and find that it is highest at young ages and then declines rapidly, and becomes insignificant at age 26. Thus, the benefit in terms of lower unemployment rates is a transitory one. This suggests that apprenticeship training provides a benefit to participants in that it improves labor market attachment early in their career. We provide further

consistent evidence for this based on firm-closures: When a young adult is hit by a negative shock through a firm closure, the benefit of apprenticeship training is lost, and the job-finding rate between the two groups is no different after that.

In summary, our results indicate that the two forms of vocational preparation deliver similar skills, but the apprenticeship training aides the initial integration of young adults into the labor market. How much weight the policy-maker places on this difference will depend on the emphasis on a smooth school-to-work transition, but the evidence on problems associated with high youth unemployment suggests that these considerations are likely to be important. Traditionally, the comparison between vocational schooling and apprenticeship training focuses primarily on the educational dimension; the results we obtain here underline the relevance of vocational training in the worker-firm matching process.

A Appendix

A.1 Description of the economy

Consider an economy consisting of regions (denoted by k), in which two products are produced (X_{1k} and X_{2k}), using two labor inputs (apprenticeship graduates, L_k^{appr}, and vocational school graduates, L_k^{school}). Technology is identical across regions (described by production functions $F_1(\cdot)$ and $F_2(\cdot)$) and characterized by constant returns to scale, and positive and diminishing marginal productivities. Assume that products are freely traded across regions, while factors are mobile across sectors but immobile across regions. Product prices $(1, p)$ are determined at the world market, where the price of good 1 has been normalized to 1.

Now consider the educational choice of the young schoolleaver, who decides between apprenticeship and vocational school. Specify utility from the two alternatives for individual i as the present value of future wages:

$$V_i^{appr} = \sum_{t=2}^{T} \left(\frac{1}{1+r}\right)^{t-1} w_k^{appr} + x_k + u_i \tag{4}$$

$$V_i^{school} = \sum_{t=2}^{T} \left(\frac{1}{1+r}\right)^{t-1} w_k^{school} \tag{5}$$

where r is the discount rate, u_i is a person-specific random utility shock; T denotes the length of the working life, so that the income stream in the main labor market is from $t = 2$ (after the initial training period) to $t = T$ (assuming that income during the training period is negligible). Annual factor rewards for apprenticeship graduates and vocational school graduates, respectively, are denoted by w_k^{appr} and w_k^{school}. Furthermore, x_k is a region-specific parameter which affects the apprenticeship option, which we interpret as local availability of an education-specific factor. Individuals choose the alternative with the higher utility, so that the resulting number of individuals who enter apprenticeship training is

$$L_k^{appr} = \sum_i \mathbb{1}\left\{\sum_{t=2}^{T} \left(\frac{1}{1+r}\right)^{t-1} \left(w_k^{appr} - w_k^{school}\right) + x_k + u_i > 0\right\} \tag{6}$$

$$\equiv g_k\left(w_k^{appr} - w_k^{school}\right), \tag{7}$$

where $g_k(\cdot)$ is an educational decision function satisfying $g_k' \geq 0$, which implies a normal factor supply.[37] Given a fixed number of schoolleavers in region k, $\overline{L}_k$, we have $L_k^{school} = \overline{L}_k - L_k^{appr}$.

The economy can be described by the following set of equations:

$$X_{1k} = F_1\left(L_{1k}^{appr}, L_{1k}^{school}\right) \tag{8}$$

[37] Findlay and Kierzkowski (1983) describe an educational choice setting between skilled and unskilled work in which education is provided by a specific factor which is competitively rewarded; their setting leads to an educational decision similar to (7).

$$X_{2k} = F_2\left(L_{2k}^{appr}, L_{2k}^{school}\right) \tag{9}$$

$$L_k^{appr} = L_{1k}^{appr} + L_{2k}^{appr} \tag{10}$$

$$L_k^{school} = L_{1k}^{school} + L_{2k}^{school} \tag{11}$$

$$L_k^{appr} = g_k\left(w_k^{appr} - w_k^{school}\right) \tag{12}$$

$$L_k^{school} = \overline{L_k} - L_k^{appr} \tag{13}$$

Define factor intensities $\rho_{1k} = \frac{L_{1k}^{appr}}{L_{1k}^{school}}$, $\rho_{2k} = \frac{L_{2k}^{appr}}{L_{2k}^{school}}$, and assume $\rho_{1k} > \rho_{2k}$. Define intensive production functions $f_1(\rho_{1k}) = F_1(\rho_{1k}, 1)$, $f_2(\rho_{2k}) = F_2(\rho_{2k}, 1)$. Assume no complete specialization: equilibrium is possible in which all regions produce both goods.

The marginal value of each type of labor must be equal across sectors:

$$f_1'(\rho_{1k}) = p\, f_2'(\rho_{2k}) \tag{14}$$

$$f_1(\rho_{1k}) - \rho_{1k} f_1'(\rho_{1k}) = p\left(f_2(\rho_{2k}) - \rho_{2k} f_2'(\rho_{2k})\right) \tag{15}$$

Now (14) and (15) determine ρ_{1k} and ρ_{2k}. Since the system (14–15) is the same across regions, we have that all regions choose the same optimal factor intensities:

$$\rho_{1k} = \rho_1 \tag{16}$$

$$\rho_{2k} = \rho_2 \tag{17}$$

This in turn pins down factor rewards:

$$w_k^{appr} = w^{appr} = f_1'(\rho_1) \tag{18}$$

$$w_k^{school} = w^{school} = f_1(\rho_1) - \rho_1 f_1'(\rho_1). \tag{19}$$

Thus, factor price equalization holds: In equilibrium, although the educational decision rule (12) is region-specific, there are no differences in factor rewards across regions.

The setting described here is an extension of the model described in Kemp (1964). Using activity analysis, McKenzie (1955, Theorem 2") proves that factor price equalization extends to the variable factor supply case if factor supplies are normal, a requirement satisfied by equations (12) and (13).

A.2 Data appendix

The analysis in this paper is based on a large administrative data set of individual employment histories for German employees, the IABS, provided by the Institute for Employment Research (IAB). A description of this data can be found in Bender, Haas, and Klose (2000). The sample contains 2% of all employees who are ever subject to social security contributions over the period 1975 to 2001. It excludes data on the self-employed, civil servants, and the military. We limit our analysis to West German males (excluding West Berlin) from the cohorts 1964 to 1975. For each individual, we record the labor market status on a reference day, June 30, of each year. We then define our sample of interest as all those individuals who are in the labor force on June 30. To focus on non-college bound youth we eliminate all individuals who hold a schooling degree from the college-bound schooling track (*Abitur*), or who ever hold a degree from a university (or a university of applied sciences) in our sample. We exclude individuals who enter the labor market later than age 24. As a measure of where the young adult grows up, we record the first employment office district in which he is recorded in the data.

Apprentices in the dual system are are a clearly identified group in the data and can be distinguished from regular workers. Since we observe the full employment history of each sampled individual, it is straightforward to establish whether an individual has ever been an apprentice, and if so, for how long. For this purpose, we compute for each calendar year whether a given individual has had the apprentice status during this year, and if so, for what fraction of the year. We also compute a cumulative version of this variable, which indicates the years of apprenticeship training up to a given age.

We compute the number of days an individual is unemployed during each calendar year, and then define an indicator which takes the value 1 if the individual has been unemployed for at least 30 calendar days. We compute log average daily wages as follows: We divide total wages (in prices of 2000) earned in full-time regular employment on a calendar year basis by the number of days spent in full-time regular employment, and then take logs. We eliminate observations which would imply a wage rate of below 1 Euro per hour (in prices of 2000), assuming an eight hour day. Wage reports in the data are generally top-coded at the social-security contribution limits, but since we focus on young workers and exclude all individuals with a college degree and from the upper schooling track, this is unlikely to be relevant for our sample. — We measure change of occupation as an indicator for a change in occupation on two consecutive reference dates, limiting attention to moves into regular full-time employment. We define industry movers similarly, and both industries and occupations are coded on a two-digit level. A key advantage of this administrative data set relative to survey-based data is that we can expect to have little measurement error; this is especially important for measures of mobility (Kambourov and Manovskii, 2008).

Apprenticeship vacancies are published annually by the German Federal Employment Office. From 1991 onwards, this data is published on the website of the Federal Employment Office. For previous years, we collect the information from annual publications of the Federal Employment Office (see, e.g. BA (1991)). We normalize the vacancy data by an estimate of the number of young people who grow up in each district. For that purpose, we compute cohort sizes at the level of the *Land* based on the number of seventeen year olds, as published by the national Statistical Office. To obtain the number of young people on the finer district level, we split this based on the district level share of 15-19 year olds in each *Land*, for which we use the 1988 shares as reported in BMBF (1992, pp. 206-208).

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A.3 Further tables

Table A.1: Apprenticeship vacancies and educational choice

	apprenticeship training (years)	**vocational degree (indicator)**
	OLS	OLS
	(1)	(2)
apprenticeship vacancies (at age 16)	0.492	0.0197
	[0.0974]***	[0.0251]
cohort fixed effects	Yes	Yes
region fixed effects	Yes	Yes
region trends	Yes	Yes
age fixed effects	Yes	Yes
year fixed effects	Yes	Yes
labor market controls	Yes	Yes
Observations	242014	242014
Mean (dependent variable)	2.182	0.796
St. dev. (dependent variable)	1.239	0.403

Note: Standard errors reported in brackets, clustered by region. * indicates significance at 10%, ** indicates significance at 5%, *** indicates significance at 1% level. See text for details.