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Abstract

A number of studies have found that firms provide less training if they are located in regions with strong labor market competition. This finding is usually interpreted as evidence of a higher risk of poaching in these regions. Yet, there is no direct evidence that regional competition is positively correlated with poaching. Building on a recently established approach to ex-post identify poaching of apprenticeship completers, our paper is the first to directly investigate the correlation between regional labor market competition and poaching. Using German administrative data, we find that competition indeed increases training establishments' probability of becoming poaching victims. However, poaching victims do not change their apprenticeship training activity in reaction to past poaching. Instead, our findings indicate that the lower training activity in competitive regions can be attributed to lower retention rates, a less adverse selection, and lower labor and hiring costs of apprenticeship completers hired from rivals.

JEL Codes: J24, M51, M53, R23

Keywords: Poaching, firm-sponsored training, apprenticeship, regional labor markets, labor market competition

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1. Introduction

Poaching – hiring of employees against the will of the current employer – is an important threat to firm-sponsored general training. Both, training firms' risk of becoming a poaching victim, and firms' willingness and ability to commit poaching are likely to depend on the degree of competition in the labor market. Yet, direct empirical evidence on the link between competition and poaching is rather scarce. Our aim is to fill this gap in the literature, using an innovative empirical strategy to identify poaching and measuring competition at the level of regional occupational labor markets. Therein, we exploit the institutional peculiarities of the German apprenticeship system.

We follow up on recent studies which find a negative relationship between regional employer competition and firms' training provision. Brunello and Gambarotto (2007) for example find a negative relationship between regional employment density, as well as industrial specialization, and employer-provided training in the UK. Similarly, Brunello and De Paola (2008) and Andini et al. (2013) detect a negative relationship between regional employment density and firm-sponsored training in Italy. Most closely related to our study, Mühlemann and Wolter (2011) find for Switzerland that the density of firms in the same region and industry is negatively related to firms' apprenticeship training activity. These studies mainly attribute lower training to poaching.

We aim at testing the hypothesis that poaching indeed is the main mechanism behind the negative correlation between regional employer competition and training. We use data on apprentice training completers and their transition to skilled employment in Germany. To identify poaching, we apply an approach developed by Mohrenweiser, Zwick, and Backes-Gellner (2013). However, they do not consider poaching in the context of regional competition.

Our three main contributions are the following. First, in line with the literature cited above, we find that establishments in highly competitive regions train fewer apprentices. Second, we find that establishments in highly competitive regions are significantly more likely to become victims of poaching. Similar to Mohrenweiser et al. (2013), we however show that poaching incidence is small and not systematic. In addition, firms do not reduce their training activity in response to poaching. Therefore, poaching - as observed ex-post at the establishment level - cannot explain the negative impact of regional labor market competition on training activity. As a consequence, our third contribution is to propose alternative explanations. We find that

availability and quality of all apprenticeship completers who leave their training firm (including non-poached movers) are higher in more competitive as compared to less competitive regions. In addition, it is costlier to train apprentices in competitive regions. Besides the better supply of attractive apprenticeship completers, their hiring and wage costs are relatively low in agglomerations. These differences between labor market regions prevail for all apprenticeship completers, they have been rarely discussed in the literature before but seem to have a much more pervasive impact than differences in the tiny group of poached apprenticeship completers.

This paper proceeds as follows. In the next section, we introduce crucial theoretical concepts of poaching and present the institutional setting of apprenticeship training in Germany, which we exploit to apply these concepts. In section 3, we review previous empirical evidence on regional labor market competition, firms' training provision, and the sparse evidence on poaching. Section 4 presents our data base, sampling design, and the identification of poaching. Section 5 analyzes apprenticeship completers' wages with regard to their mobility and regional demand-side competition. Section 6 presents econometric specifications and estimation results of the correlation between regional labor market competition, apprenticeship training, and poaching. Section 7 discusses the implications of our empirical findings for the labor market more generally, and provides alternative explanations of the regional training patterns. Section 8 concludes.

2. Theoretical and institutional background

2.1 Apprentice training, imperfect competition, and poaching

We regard it as poaching when worker mobility between firms is a consequence of an active attraction by the hiring firm ("raider") and against the will of the sending firm ("victim"), a concept underlying, e.g., the theoretical work of Combes and Duranton (2006). Poaching is obviously problematic with regard to workers who have recently received training sponsored by their employer. Our focus is therefore on workers in Germany who just completed an apprenticeship. For these workers, training firms have devoted time and money, usually incurring net costs during the training period (Soskice, 1994; Mohrenweiser and Zwick, 2009; Dionisius et al., 2009). These training investments only pay off in the longer run if the apprenticeship completer stays with the training firm for some time (Acemoglu and Pischke, 1998).

We consider as potential cases of poaching only job moves immediately after apprenticeship completion, or in other words, job moves that occur before the firm's training investments can

pay off. In addition, we want to make sure that the termination of the employment relationship directly after the apprenticeship training period is involuntary from the perspective of the training firm. Therefore, we concentrate on those apprenticeship completers with the highest productivity during apprenticeship training who in addition earn more at the new employer than their peers at the training firm (Mohrenweiser et al., 2013). Such an event is obviously undesirable to the training firm, and a rational training firm should want to avoid it. We seek to ensure that observed poaching events reflect free-riding on another firm's training investment, by only considering mobility within occupations. Thereby, we exploit one of the central features of the German apprenticeship system, the transferability of occupation-specific training contents between firms. We briefly present crucial features of the German apprenticeship system before we turn to the possibility and observability of poaching.

The "dual" apprenticeship system is the main source of occupational qualification in Germany. As of 2014, half of the German working-age population held a vocational degree – usually acquired through an apprenticeship – as their highest qualification.[1] The German apprenticeship system makes poaching perfectly viable for a number of reasons. One reason why training firms can hardly prevent poaching is that they cannot force trained workers to stay for some time after training completion. It is therefore highly unlikely that non-compete covenants are made and enforced for apprenticeship completers.[2] Furthermore, there are no legal restrictions to make job offers to apprenticeship completers and to the wages offered to them. Apprenticeship completers also do not have to reimburse training costs if they switch the employer directly after training. It is also helpful for potential rival employers that all apprenticeships in one region and occupation end on the same day (the date of the final exam held in the chambers of industry and commerce or chambers of crafts). In addition, it is known to establishments which other establishments in the region train apprentices and in which occupation. Thus, a rival firm can easily outbid a training firm by offering a higher wage for a trained worker.

Another important aspect for the viability of poaching is that training contents are transferable and apprenticeship completers can signal their acquired skills to other firms. Apprenticeships are strongly regulated by the Vocational Training Act and the occupation-specific training curricula. The Vocational Training Act specifies the duration of training, necessary equipment and staff in charge of training, and other requirements for training firms. Training curricula are

[1] Federal Statistical Office (2015).

[2] Starr (2015) reports differences in non-compete covenants between US states and occupations. He uses these differences to empirically show a positive correlation between the strength of non-compete enforcement and training intensity mainly in high education and high earnings occupations.

published, tailor-made for each occupation, and describe minimum standards which have to be met for a successful training completion. Apprenticeships are essentially employment contracts combining on-the-job training with actual productive work. One to two days per week are spent on theoretical contents in public vocational schools. These contents are necessarily general human capital. The chambers additionally monitor the quality of practical training provided in each training establishment in their region, notably by intermediate exams taking place halfway through the apprenticeship. Therefore training contents can be characterised to a large extent as general human capital within the occupational domain (Acemoglu and Pischke, 1998). Apprenticeship completers in addition receive certificates from independent bodies that also grade the final examinations (vocational schools and chambers) that signal a minimum skill level (Acemoglu and Pischke, 2000). Certificates therefore signal the individual quality relative to those apprenticeship completers trained in the same occupation (Mohrenweiser, Wydra-Sommaggio, and Zwick, 2015). Considering all these institutional features, it is easily possible to identify apprenticeship completers in all training firms who are worth poaching, with a high degree of certainty about individual quality.

Poaching can be profitable for the raider since the training has increased the worker's productivity, but the raiding firm has not contributed to the costs of training – it free-rides on the training firm's investment. Furthermore, to the extent that a raider can observe a worker's productivity relative to other workers at the training firm, it also free-rides on the revelation of apprentices' individual productivity during the training period. The raider thus extracts a rent from the training firm and also weakens a potential competitor in the product market if it can attract a highly productive apprenticeship completer for a wage not higher than his or her productivity. Therefore, raiding can be a profit-maximizing strategy. Poaching however requires raiders to compete with training firms for their apprenticeship completers. Therefore, poaching is only successful if the raider is strong enough to counter the monopsony power of the training firm. This monopsony power mainly stems from three sources.

The first source of training firms' monopsony power is their information advantage regarding apprenticeship completers' quality (Chang and Wang, 1996, Acemoglu and Pischke, 1998). This information advantage implies that apprentices who are not retained by the training firm are an adverse selection (Greenwald, 1986). Empirical evidence of such adverse selection is provided by Mohrenweiser et al. (2015). They attribute the negative selection of moving apprenticeship completers to training establishments' information advantages on soft skills. They also argue however that learning about hard skills is symmetric for training employers and their

potential rivals because these skills are visible from the graded final exams. Even though movers are negatively selected on average, however, a rival firm may offer a higher wage to attract particularly well-performing apprenticeship completers.

The second source of monopsony is the costliness of regional mobility. Mobility costs give local employers market power over workers, compared to more distant employers (Manning, 2011; Benson, 2013). Note that apprenticeship completers are immobile in comparison to higher educated and older employees. This emphasizes the importance of spatial monopsony (Harhoff and Kane, 1997). Thus, the level of competition for a firm's apprenticeship completers crucially depends on the number of other employment opportunities within a certain region.

The third source of monopsony power is losses incurred by a change of occupation. The main reason for this third source of monopsony power is that occupations are an important dimension of human capital specificity (Kambourov and Manovskii, 2009; Sullivan, 2010). Manning (2003) emphasizes the importance of occupational boundaries in generating monopsony power. In Germany, the labor market for skilled employees – and for apprenticeship completers in particular – is mainly defined along occupational demarcation lines (Deißinger, 2008). As a consequence, occupation changes are associated with worse wage outcomes than employer changes within an occupation (Göggel and Zwick, 2012; Fitzenberger et al., 2015). Failing to account for the importance of occupations thus leads to mismeasurement of competition for apprenticeship completers. We therefore only consider apprenticeship completers who do not switch their occupation and define regional competition on the basis of occupational labor markets as in Benson (2013).

2.2 Poaching as a regional externality

Poaching has received scholarly attention particularly in regional economic theory. Combes and Duranton (2006) for example develop a model to grasp the trade-off between the benefits of locating close to other firms (input sharing, labor pooling, knowledge spillovers) and its detriments (poaching and higher wages to prevent it). The main assumptions and implications of their model can be summarized as follows: First, co-location of firms is a necessary condition for poaching, since worker mobility is spatially bounded. Second, firms co-locate nevertheless if the benefits of co-location outweigh its costs. Several theoretical papers thus discuss firm location in the face of a poaching threat. Rotemberg and Saloner (2000) suggest that immobile workers are more likely to invest in industry-specific human capital if there is competition between regional employers – a regional monopsony could exploit workers' mobility constraints

by paying wages below their marginal product. As a consequence, firms which depend on the supply of industry-specific skills have to face a certain amount of competition. However, the model explicitly rules out firm-sponsored training. Matouschek and Robert-Nicoud (2005) and Almazan et al. (2007) propose models in which firms choose a location depending on the financing of their employees' training, with isolation being the preferable choice if the firms bear a high share of the training costs. These theoretical approaches all point towards a negative relationship between local competition and firm-sponsored training activity, such as apprentice training.

Yet, there is little empirical evidence on whether training firms actually choose isolated locations (thus forgoing positive agglomeration externalities) if they are vulnerable to trained-worker poaching. In our analysis, we also cannot control whether the fear of poaching influences the complex location decision of firms. However, as Mühlemann and Wolter (2011) argue, firms are not likely to choose their location based on their training activities because the average training establishment spends just about one percent of its skilled-worker wage bill on apprentice training. Apprentice training, while important, is not the core business of any firm, and should therefore be a minor factor in firms' location choices. If anything, training establishments may adjust their training activity downwards in anticipation of a competition-induced poaching threat. However, the available measures of competition (typically, the number of other employers in the same region and industry or occupation) do not vary much over time, so anticipation effects should play a minor role. Therefore, we take firms' location as given and regard it as unlikely that reverse causality is an important problem for our analysis.

Related evidence on the positive correlation between agglomeration and labor market competition is provided by Hirsch, Jahn, and Oberfichtner (2016) for German regions. Their study approaches employer competition via an analysis of the urban wage premium and its sources. They show that the urban wage premium is to a large extent due to tougher employer competition in dense labor markets. The results of Hirsch et al. (2016) have important implications for our analysis. In particular, they point to the importance of employer competition for individual labor market outcomes, notably wages: Firms in dense regions need to offer higher wages in order to attract workers, which may offset the greater ease with which they can find suitable workers. Firms may also need to use aggressive hiring strategies, such as poaching. These findings suggest that indeed, regional competition may increase the incidence of poaching. However, there is little empirical evidence to support this claim, with the exception of studies on the

link between regional competition and firms' training provision. We review these studies in the next section.

3. Previous empirical evidence on regional labor market competition and poaching

The empirical analysis of poaching and firm-sponsored training is largely rooted in the literature on agglomeration effects that arise from economies of scale and spatial concentration of workers and firms (Marshall, 1890). This literature emphasizes worker mobility as an important channel of agglomeration externalities (labor pooling and knowledge spillovers). For a more recent theoretical discussion of these channels, see Duranton and Puga (2004). Empirical evidence on the positive effect of regional labor market density on labor turnover is provided by Andersson and Thulin (2013), who find this effect to be even stronger for more highly qualified workers. Similar results are obtained by Mühlemann, Ryan, and Wolter (2013) and Hirsch, Jahn, and Oberfichtner (2016), who also find that wages are higher in denser (and hence more competitive) regions, in order to limit the turnover of skilled employees. Moreover, there is ample evidence that worker mobility in dense regional labor markets is concentrated within industries and occupations (Bleakley and Lin, 2012; Andini et al., 2013), that is, dense regional labor markets allow for a better skill match between workers and firms (as predicted by theories of agglomeration advantages). Against this background, and because within-industry and within-occupation mobility allows for a better transfer of skills and knowledge acquired on the job, employers in dense regional labor markets are expected to be particularly reluctant to provide training to their workers. Empirical studies indeed find a negative relationship between regional competition and firm-sponsored training (Brunello and Gambarotto, 2007; Brunello and De Paola, 2008; Mühlemann and Wolter, 2011; Andini et al., 2013).

An early empirical study on Germany, closely related to ours, was conducted by Harhoff and Kane (1997). Motivated by the stark contrast between German-style apprentice training and the absence of such a training system in the US, Harhoff and Kane (1997) identify the relatively low levels of regional mobility in Germany as a factor which favors training. They argue that workers' limited spatial scope of job search gives training firms monopsony power over their trained workers. If worker mobility across regions is low, one can use regional variation in the number of potential employers to investigate the effect of regional employer competition on firms' training provision and recruiting behavior. Accordingly, Harhoff and Kane (1997) stress that regional firm and employment densities are significantly negatively related to firms' training participation and the share of apprentices trained.

The link between regional labor market competition and firm-sponsored training has been investigated also for other European countries and the US. Using data from the UK on employer-provided training, Brunello and Gambarotto (2007) study the relationship between individual workers' training participation and regional labor market competition.[3] Brunello and Gambarotto (2007) find a negative effect of regional employment density, measured at the NUTS 2 level (groups of counties), and industrial specialization on workers' participation in and the duration of firm-sponsored training. The negative effect of employment density on training as such is very robust, and its interaction with average regional firm size has a positive effect on training. This suggests that the threat of poaching more severely decreases firms' training provision in regions characterized by smaller firms, i.e. regions where competition can be expected to be stronger. Brunello and Gambarotto (2007) do not identify poaching directly, but they show that regional density has a positive impact on voluntary job mobility, even more so for workers who have recently received training. Since part of the overall amount of voluntary job mobility could be instances of poaching, Brunello and Gambarotto (2007) argue that trained workers are more likely to get poached by other firms as regional employment density increases.

In a related firm-level study, Brunello and De Paola (2008) derive from a search and matching model that regional employment density could be negatively correlated with employer-sponsored training. Using Italian data and measuring employment density at the NUTS 3 region level, they show that the (assumed) negative poaching externalities dominate potential positive (complementary) agglomeration effects on training. That is, it is assumed that agglomeration (employment density) is a source of both positive and negative externalities. Brunello and De Paola (2008) address endogeneity concerns by instrumenting regional employment density with historical lags (from the late 19th and early 20th century), suggesting that their findings represent a causal relationship. Similar to Brunello and Gambarotto (2007), the negative training effect of employment density is found to be driven by small firms and not for firms which are part of "industrial districts," supposedly because such districts are founded on co-operative relationships between employers, which poaching would undermine. Benson (2013) stresses that US hospitals subsidize nursing schools in their region. These schools provide general training for all trainees who remain active in the nursing occupation. His argument is that low regional mobility of nurses and few attractive occupational options outside nursing provides hospitals

[3] An important difference between the study by Brunello and Gambarotto (2007) and our study is that any kind of employer-provided training is considered, including continued vocational training. Compared to German-style apprentice training, therefore, their data may contain a large share of relatively firm-specific training, which should be less susceptible to poaching.

with sufficient monopsony power to invest in general training. An important result of the study is that the incentive for subsidies increases with the market share hospitals have in the occupational labor market for nurses.

The delineation of regions used to measure competition in the above-cited studies (administrative territorial units) may not capture competition very accurately, since commuting flows may reach across administrative borders. A functional definition of labor market regions based on commuting flows is thus better suited to capture competition faced by a firm in a given location (Kosfeld and Werner, 2012). Therefore, Mühlemann and Wolter (2011), who also analyze firms' training activity with regard to regional competition, apply a definition of regional labor markets based on travel time. Their study is a close reference to our analysis because it uses data on apprenticeship training in Switzerland. The Swiss apprenticeship system is very similar to Germany's, regarding the importance of on-the-job training, generality of contents, and standardization of final exams. Mühlemann and Wolter (2011) find that the regional density of firms in the same industry is negatively related to firms' training provision. This pattern is robust, inter alia, to the inclusion of region fixed effects. The negative effect of density is found to be driven primarily by firms abstaining from training altogether, rather than training fewer apprentices. Mühlemann and Wolter (2011) also show that the observed negative training effects apply only to firms which bear net costs of training. This means that regional competition is relevant only to training firms who would lose their training investment when being poached. This finding supports the interpretation that firms' lower training efforts reflect fear of poaching.

Finally, using Swiss data, Mühlemann, Ryan, and Wolter (2013) find that the number of establishments in a regional industry increases apprentices' (and skilled workers') pay relative to unskilled workers and their turnover rate relative to the national average of workers in the same occupation. The relative-wage effect of competition reflects firms' monopsony power over apprentices: When there are fewer local competitors, there is less need to provide a wage incentive to one's own apprentices and skilled workers to stay with the firm. The positive effect of local employer competition on skilled-worker and trainee turnover therefore might be due to a higher incidence of poaching in more competitive regions.

Overall, thus, related studies find a positive effect of regional competition on trained workers' wages and turnover rates, and a negative effect on firms' training provision. The authors usually attribute the latter effect to a higher poaching risk. Despite the substantial body of evidence on the regional determinants of training activity, direct evidence on regional competition and

poaching is scarce, however. We can contribute to this literature in several ways. The above-cited studies take it as given that competition affects firms' training decisions through the poaching risk, but none of them identifies poaching empirically. Applying the identification strategy for poaching proposed by Mohrenweiser et al. (2013), we investigate the relationship between employer competition and poaching directly and analyze the consequences of poaching for training efforts. We use occupational labor markets as indicator of regional competition instead of regional industries. Occupational barriers are particularly important for apprenticeship completers because their training is almost perfectly transferable across firms if they stay in the occupation. We accordingly only include apprenticeship completers who do not change their occupation. Firms are usually assigned unambiguously to one industry, but especially large firms may demand labor across a broad range of occupations, some of which are likely relevant also to other industries.[4] Therefore, a purely industry-based identification of potential competitors neglects occupations that are less typical for one's own industry, and also neglects relevant competition from other industries. Besides the poaching analysis, we also look at differences between regional labor markets with respect to decisive drivers for apprenticeship training such as the availability and quality of employer movers and their costs in comparison to the costs of own training. In the next section, we present the data and empirical study design used in our empirical analysis.

4. Data

4.1 Data sources and sampling

The data bases we use are the Institute for Employment Research's (IAB) Employee History Panel (*Beschäftigtenhistorik*; BeH) and Establishment History Panel (BHP). The BeH and the BHP are generated from public employment records, administered by the Federal Employment Agency (BA), which serve as the basis for social security contributions. Besides the exact beginning and end dates of employment spells, these data include gross daily wages,[5] workers' level of qualification and occupation, their employers' industry and location at the NUTS 3 level (*Kreise* or districts), and a host of other variables. Since misreporting of data is subject to pecuniary sanctions, these data are highly reliable. Moreover, the BeH cover the universe of

[4] Some of the most frequent training occupations in our sample are used in many industries, for instance clerical workers (18% of apprenticeship completers), electricians (12%), and locksmiths (11%).

[5] Wages are censored at the top. However, the censoring threshold is the social security contribution limit, and therefore censoring does not affect apprentices' wages (which are usually less than half the wage of a qualified full-time worker).

employment subject to social security in Germany, which excludes only civil servants and the self-employed. The BeH thus contain some 80 percent of all employees in Germany, and 100 percent of apprentices in the "dual" apprenticeship system, because they are employees subject to social security contribution at their training establishments.[6]

We sample establishments and apprentices as follows. We choose all establishments which were surveyed in the IAB Establishment Panel between 2003 and 2011.[7] This panel covers all industries except public authorities and not-for-profit establishments. We drop the public sector, non-profit establishments, as well as the agricultural sector, resulting in a sample of profit-oriented business establishments. Administrative employment data at the establishment level are taken from the BHP, a yearly panel resulting from an aggregation of the employment records of the BeH. These data contain all establishments in Germany with at least one employee subject to social security contribution, measured at June 30th of that year. At the individual level, we sample all employment spells from the BeH of all persons who were employed as apprentices at any of the sample establishments at some point in time between 1999 and 2010 (1.25 million persons). We follow these persons over time, focusing on their transition from apprenticeship to regular (skilled) employment. To sort out the apprenticeship completers for whom we can potentially observe poaching, we apply the following criteria to the sampled employment spells:

First, we consider only apprenticeships that took between 700 and 1,500 days. Shorter apprenticeship periods probably indicate drop-outs, longer durations may include exam repeaters because most apprenticeships take at most 3.5 years. We omit these individuals so as to obtain homogenous groups of apprentices and be able to assess their relative individual quality. We allow for some time of employment interruption, e.g. for sickness leave during the apprenticeship period. We also require that apprenticeships start between June and December, and end between January and August, since the hiring and final exam periods usually fall into these months, respectively.

Second, since wages are an important variable for our identification of poaching, we remove extreme wage outliers, defined as apprentices who earn more than twice or less than half the average wage in their two-digit occupation and apprenticeship completion year.

[6] See Vom Berge et al. (2013) for further information on the BeH.

[7] The IAB Establishment Panel is a large establishment survey from which we can merge additional information not contained in the administrative data.

Third, since we want to identify poaching of successful apprenticeship completers,[8] we need to identify a transition from apprenticeship to regular employment. To be more specific, we only include apprentices who become employed in a full-time job as their first employment after completing apprenticeship training. We ensure that the job is not an internship or otherwise non-regular kind of employment.

Fourth, we construct so-called "cells" that contain all successful apprenticeship completers within one establishment, two-digit occupation, and completion year, and keep only cells with at least two apprentices. The reason for this sample restriction is that we need to compare individual apprentices to a peer who potentially moves to another firm to identify poaching.[9]

Fifth, we drop cells in which all apprenticeship completers leave their training establishment because we need the comparison group of retained apprenticeship completers.

Sixth, we keep only apprentices whose transition to regular employment occurs within ten days after the observed end of their apprenticeship, and who stay within the same two-digit occupation. These restrictions ensure that training establishments are not able to get a return on training investments by employing the apprenticeship completer at a low wage for some more weeks or months after training completion.

Finally, there are some obvious outliers for the first wage as a fully qualified worker after apprenticeship training. We therefore drop apprenticeship completers for whom a gross daily wage below 10 or above 500 Euros is reported.

Applying all of these conditions results in a restricted sample composed of apprenticeship completers of rather large training establishments, which might not be representative of the population of apprenticeship completers and training establishments. To check whether our results may be driven by these sample restrictions, we construct a broader so-called "baseline" sample of apprenticeship completers, their training establishments, and the destination establishments of moving apprenticeship completers. This baseline sample is drawn analogously to the poaching sample with the exception that some of the strict conditions we have to impose to identify

[8] We cannot identify apprenticeship completion directly, but our restrictions regarding apprenticeship duration and transition to regular employment allows us to identify completion very plausibly.

[9] We have to ensure that changes of the establishment identifier number reflect true changes of employer. This is potentially problematic with the data at hand because the establishment identifier does not always correspond to a single autonomous establishment, but may instead identify a plant, store, office, or other kind of branch belonging to the same company, and being located in the same district. We address these issues in several ways, as discussed in the subsection "Spurious worker mobility" in Appendix B.

poaching are suspended (see an overview of the sample generation steps in Table B1 in Appendix B).

4.2 Identification of poaching

We proceed to identify poaching of apprenticeship completers. To be counted as poaching, a job move by an apprenticeship completer should satisfy two conditions: First, the move should be undesirable and unintended from the training firm's perspective. Second, the move should be accompanied by an active effort on the part of the hiring firm, that is, there should be an incentive set by the hiring firm to attract the apprenticeship completer. As argued by Mohrenweiser et al. (2013), it is plausible to assume that the most desirable apprenticeship completers receive the highest wages within their peer group (the "cell" defined by the same establishment, training occupation, and completion year) during their last apprenticeship spell. Therefore, we can interpret an apprenticeship completer's relative wage at the end of the apprenticeship as a signal of the training employer's intention to retain him or her as a skilled employee. Furthermore, we can use apprenticeship completers' skilled entry wages to infer which job moves were likely triggered by an attractive wage offer from an external hiring firm. We take these ideas to the data as follows. Within each cell, we compare wages between those who stay with the training establishment and those who move to another employer. If a mover's wage at the end of the apprenticeship is higher than that of the best-paid stayer in the same cell, the mover satisfies our first poaching condition (P1): The training firm would have liked to keep him or her, considering that it does keep one or more comparable apprentices who earned less at the end of the apprenticeship.[10]

An important precondition for the validity of our first poaching condition is that wages vary across apprentices within a training establishment/completion year/training occupation cell, and that this variation is not spurious. In fact, there is substantial variance in training wages within cells, and it increases markedly towards the end of an apprenticeship, see Figure 1.[11] Employers therefore increasingly differentiate apprentice pay as the final exam approaches. We take the wage variance as evidence that employers signal desirability to their best apprentices by paying them relatively high wages and incentivizing them to stay after training completion. Conversely, it seems rational to pay lower wages to less desirable apprentices, in order to limit the

[10] Note that the first poaching condition does not rule out the possibility that the establishment has intended from the beginning to retain only a fraction of its apprentices. In this case, training establishments are most likely to get rid of the apprenticeship completers at the bottom of the within-cell wage distribution (see the descriptive analysis for evidence that movers' wage positions are significantly worse than stayers').

[11] A typical three-year training period lasts from September, year t, until June/July, year t+3.

sunk costs of training. Further evidence motivating the use of the wage position within the cell as an indicator of apprentices' desirability is presented in Mohrenweiser et al. (2013), Appendix A. In particular, wage positions in the final apprenticeship year have been found to correlate with external productivity indicators such as exam grades (Mohrenweiser et al., 2015).

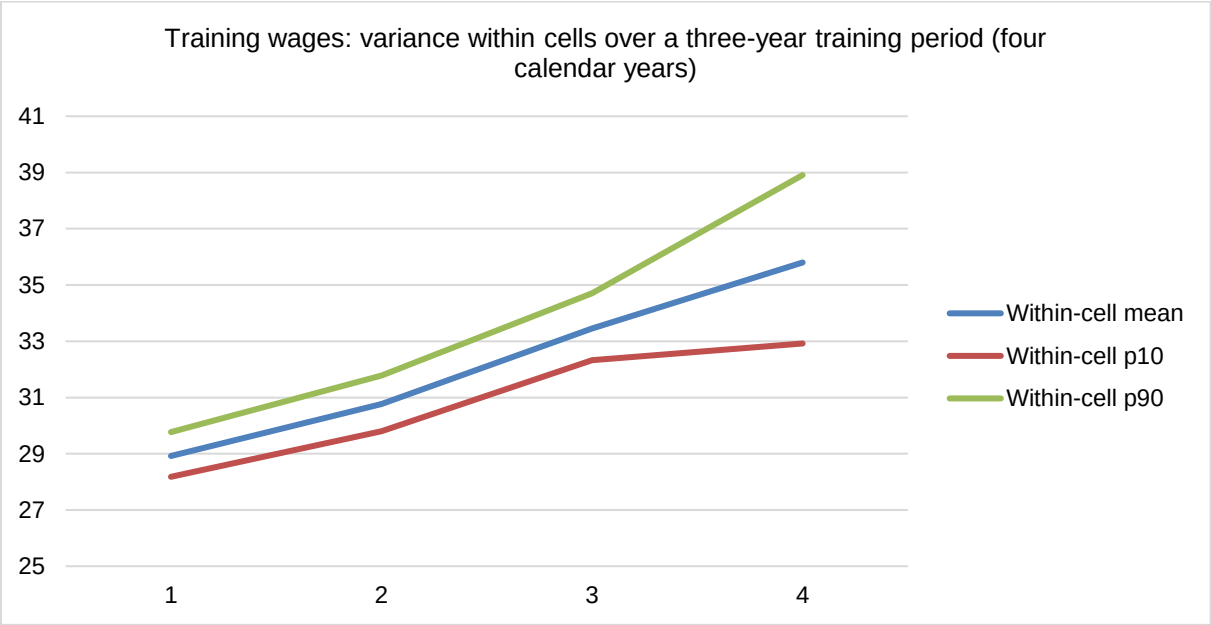

Figure 1: Development of training wages and their variance within a cell during apprenticeship training

Our second condition for poaching (P2) is that, after having moved to another employer for his or her first skilled job, an apprenticeship completer receives a higher wage than any of his or her peers who stayed at the training establishment. We consider the highest wage of a stayer within a cell as the training establishment's revealed maximum willingness (or ability) to pay. If a mover receives a wage higher than this benchmark, we interpret this as a bidding competition between the training and hiring establishments which the latter has won.[12]

In combination, the two poaching conditions imply that an apprenticeship completer whom the training establishment would have liked to keep moves to another employer that offers a wage the training firm is unwilling or unable to counter. We refer to training establishments which lose at least one apprenticeship completer due to poaching as "victims," the remaining training establishments that are not poaching victims are referred to as "controls." Analogously, with respect to the external hiring establishments, we refer to the destinations of poached appren-

[12] The hirer probably incurs a winner's curse, because the training establishment has an information advantage concerning the apprentice's productivity and might not be willing to retain the apprenticeship completer at the wage offered by the hirer.

ticeship completers as "raiders," and to all other destinations of moving apprenticeship completers from the victims and controls employers as "other hirers." Figure 2 provides an overview of the training and hiring establishment samples and the apprenticeship completer movements between establishments.[13] In the baseline sample, we distinguish training and hiring establishments, but not victims and controls, respectively raiders and other hirers.

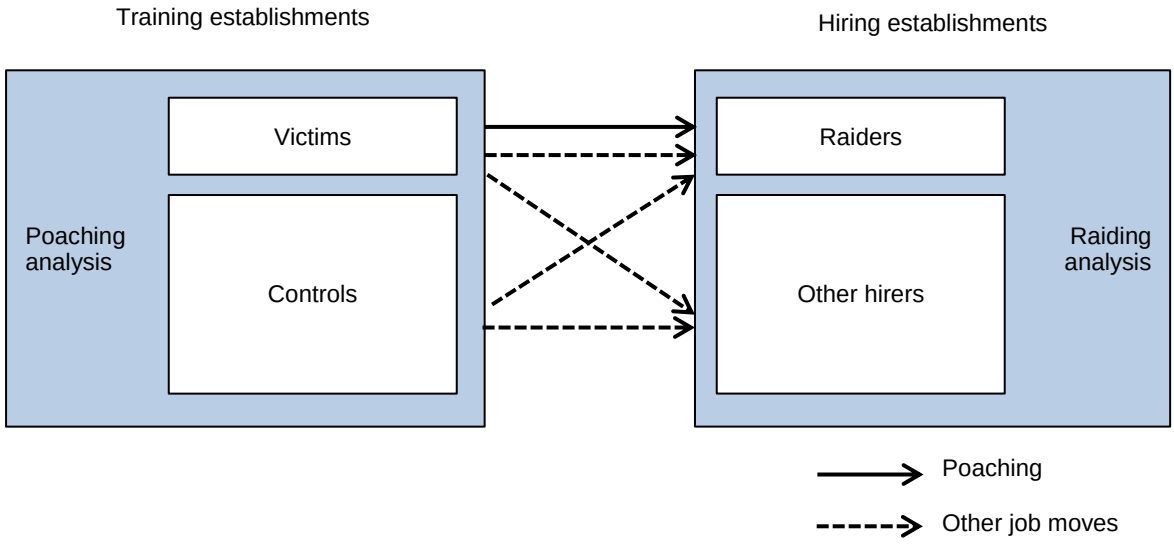

Figure 2: Employee flows between establishments in the training and hiring sample

In both, the "poaching" and the baseline sample, we drop extreme outliers in terms of their apprentice share in total employment, i.e. observations above the 99th percentile. These observations might be parts of a firm that are devoted exclusively to apprentice training (training facilities). Furthermore, we delete the top percentile in terms of employment growth, because these firms might pursue exceptionally aggressive hiring strategies and bias the incidence of poaching upwards.

4.3 Samples and descriptive statistics

Table 1 summarizes the two samples used in the analysis. Our poaching sample comprises 21,416 training establishments with 134,602 apprenticeship completers. Some eight percent of apprenticeship completers leave their training establishment within ten days after training completion to start working for one of 5,811 external hiring establishments. The larger baseline sample necessarily yields a higher share of immediate movers, at 11.4 percent. Otherwise, the

[13] By definition, an establishment cannot be a poaching victim and a control establishment at the same time, but it can be a poaching victim in one year and a control establishment in another. The same rule applies to raiders and other hirers.

characteristics of apprenticeship completers do not differ substantially between the two samples, as reported in Table A1 in the Appendix. In the poaching sample, 0.6 percent of apprenticeship completers (eight percent of all movers) are poached. Both poaching conditions (P1 and P2) contribute to similar amounts to poaching, as shown by the percentage of movers fulfilling either of the two conditions; the measured poaching incidence is thus not driven primarily by one of the two conditions. The share of "raiders" in all external hiring establishments is about eleven percent, similar to the share of poached individuals of eight percent. Tables A2 and A3 in the Appendix provide summary statistics at the establishment level for the poaching and baseline samples, respectively.

Poaching sample	**N**	**n**	**Share of Total (N)**	**Share of Total (n)**
Apprenticeship completers (Total)	134,602	134,581		
- Stayers	124,475	124,458	0.925	0.925
- Movers	10,127	10,127	0.075	0.075
- Poached movers	855	855	0.006	0.006
- Movers satisfying P1	2,643	2,643	0.02	0.02
- Movers satisfying P2	2,363	2,363	0.018	0.018
Training establishments (Total)	21,416	4,639		
- Victims	559	409	0.026	0.088
- Controls	20,857	4,230	0.974	0.912
External hiring establishments (Total)	5,811	3,519		
- Raiders	623	516	0.107	0.147
- Other hirers	5,188	3,003	0.893	0.853
All establishments	27,039	7,926		
Baseline sample				
Apprenticeship completers (Total)	196,697	196,066		
- Stayers	174,282	173,814	0.886	0.887
- Movers	22,415	22,396	0.114	0.114
Training establishments	58,632	21,033		
External hiring establishments	14,723	10,624		
All establishments	72,402	30,084		

Table 1: Descriptive statistics. N is the number of observations and n is the number of unique individuals or establishments. Sum of n(stayers) and n(movers) may exceed n(completers) because of multiply observed completers who both stay and move. Sums of training and hiring establishments may exceed number of all establishments because of overlap.

Our central empirical question is whether apprenticeship completers' employer moves, including poaching, are related to regional labor market competition. Figure A1 in the Appendix shows the geographical pattern of the mover share – the inverse of the retention rate – for the

141 German labor market regions.[14] The map suggests that overall, larger, more agglomerated labor market regions (e.g. the areas around Berlin, Munich, Stuttgart, and Frankfurt) tend to have higher shares of movers among all apprenticeship completers, but the relationship between agglomeration and turnover is not very pronounced. Figure A2 displays the share of poached movers in all apprenticeship completers. This variable does not seem to correlate with agglomeration. However, agglomeration is not synonymous for competition, and so this merely descriptive look might not capture the potential correlation of poaching with regional competition. Furthermore, our poaching identification is based on relative earnings of apprenticeship completers and wage differences between those who stay with the training firm and those who move to another employer. Previous studies indicate that besides employer mobility, also earnings of trained workers are affected by regional labor market competition (Mühlemann et al., 2013). We therefore proceed to a deeper analysis of apprenticeship completers' wages and their job mobility and their correlation with regional competition before we present our poaching analysis.

5. Regional wage analysis

Analogously to previous studies (Fitzenberger et al., 2015; Mohrenweiser et al., 2015), we expect to find that non-retained apprenticeship completers (movers) earn lower wages than those who are retained by their training establishment, reflecting an adverse selection of movers on average. Besides training wages,[15] we also consider apprenticeship completers' relative wages, that is, their deviation from the mean of the cell (training establishment, training occupation, and cohort). By referring to peers in the same cell, the relative wage is a direct measure of individual relative productivity or quality from the viewpoint of the training firm. We argue that the relative productivity of an apprenticeship completer is a good indicator of the attractiveness of the trained employee to be retained by the training firm.

We report results from regressions of these wage measures on a dummy for movers and occupation fixed effects in Table 2. We cluster standard errors at the level of regional occupational labor markets because the relevant labor markets for apprentices are bounded spatially and by occupations. Since we do not need the poaching variable in this step of the analysis, we report

[14] Note that our sample contains at least 12 apprenticeship completers and at least 5 training establishments for every labor market regions, and roughly 2,000 completers and 300 establishments on the region average. Thus, the sample can be considered fairly representative at the regional level.

[15] Unless otherwise specified, "training wages" refers to wages during the last spell of an apprenticeship, i.e. at training completion.

results using the broader baseline sample in the main text and results based on the poaching sample in the Appendix. The results suggest a significantly negative correlation between moving (not being retained) and both the absolute training wage and the within-cell wage position. For the absolute wage (columns 1-3), adding basic controls (establishment size, regional employment density) does not affect the estimate, which implies that movers' training wages are some two percent lower than stayers' on average. The relative wage (column 4) is already cleared of confounding factors at the establishment and other higher levels, and apprentices within cells are virtually identical with respect to age, education, and any other individual-level characteristics. This explains the extremely low explanatory power of the regression.[16]

	(1) log training wage	(2) log training wage	(3) log training wage	(4) Training wage rel. to cell mean
Mover	-0.0241*** (-3.85)	-0.0183*** (-2.98)	-0.0213*** (-3.46)	-0.228*** (-3.14)
log full-time employment, estab.		0.0507*** (22.35)	0.0466*** (19.70)	
log empl. density, region			0.0331*** (6.66)	
Constant	3.279*** (42.88)	3.123*** (43.24)	2.983*** (40.55)	7.53e-08 (.)
Observations	196697	196500	196500	196697
R^2	0.251	0.331	0.338	0.000
Adjusted R^2	0.251	0.330	0.338	-0.000

Table 2: Wage statistics of movers compared to stayers, baseline sample. t statistics in parentheses. All estimations include 2-digit occupation fixed effects. Standard errors clustered at region-occupation level (labor market regions, 2-digit occupations). * p<0.10, ** p<0.05, *** p<0.01.

We obtain similar results for the narrower poaching sample, see Appendix Table A4. Our findings thus suggest that movers are adversely selected on average. These findings suggest that training establishments succeed in retaining their best apprenticeship completers. However, the findings may also indicate that training establishments' monopsony power is limited: They need to pay competitive wages to incentivize their more productive completers to stay, resulting in high average wages for stayers. Furthermore, movers may incur a wage penalty due to statistical discrimination, as they are negatively selected on average (Schönberg, 2007). In combination,

[16] The relative wage is not transformed into logs because its mean and median are obviously close to zero.

both factors imply that stayers can demand higher wages than movers also after transition into a skilled job.[17]

The findings above imply that apprenticeship completers' wages reflect competition in the labor market, an important precondition for the validity of our identification of poaching. We can test this implication more explicitly by investigating the relationship between wages and regional competition. We measure regional competition as the log density (number per square kilometer) of establishments in the regional occupational labor market, that is, establishments within the same labor market region with at least one employee in relevant occupations.[18] We leave aside the individual wage position, which is informative only with regard to heterogeneity within training cells (i.e. heterogeneity at the individual level). Instead, we consider the standard deviation (SD) of training wages at the cell level, as an indicator of wage differentiation within training establishments.[19] Additionally, we compute the difference between skilled wage (the wage earned directly after transition into skilled employment) and training wage. This difference can be interpreted as the quality-adjusted wage of an apprenticeship completer and therefore as a proxy of his or her effective wage costs. This assumes that training wages contain information on the value of the apprentice from several sources. First, large and prestigious training firms may pay more for all apprentices. Second, in occupations and during phases of the business cycle in which it is difficult to attract good apprentices, training firms might offer a bonus to the collective bargaining training wage, and finally we have seen above that training firms differentiate between apprentices in the same cohort and occupation according to their relative quality.

Results from bivariate regressions are presented in Table 3. Training wages and their standard deviation within cells (establishment, occupation, cohort) are higher in highly competitive regions. These findings are in line with the hypothesis that training wages are used by training firms as signals for their intention to retain apprentices (Mühlemann, Ryan, and Wolter,

[17] We do not report skilled-wage comparisons between stayers and movers because movers' destination establishments differ systematically from the training establishments (notably, the latter are much larger, due to requirements of the poaching identification). We found that controlling for establishment size and other available variables is insufficient to reduce the implied bias to an acceptable level.

[18] More precisely, regional competition is measured for training establishments on the basis of all training occupations, and for hiring establishments, on the basis of all observed hiring occupations (we do not observe all external apprenticeship completer hirings for these establishments). Each occupation is weighted by its share in all trained (respectively observed hired) apprenticeship completers. Due to the definition of labor market regions, which are relatively homogenous in geographic size, it is virtually irrelevant whether we measure competition as the number or the density of regional competitors.

[19] Training wages (and their SD) are regressed on the competition faced by the training establishment; first-job wages and the wage difference between first job and training are regressed on the competition faced by the hiring establishment (which may be different from the training establishment).

2013).[20] Furthermore, training establishments differentiate wages more strongly within training occupations if regional competition for apprenticeship completers in the occupation is stronger. A plausible interpretation of this finding is that firms respond to regional competition by incentivizing their best apprentices to stay, while paying relatively low wages to less desirable apprentices (whose wages become sunk costs in the case of non-retention). The wage difference between training and skilled work is, not surprisingly, also positively correlated with regional competition. Basic controls (establishment size and regional employment density) are presented in Tables A5 through A7 in the Appendix, leaving the results largely unchanged.[21] Using the smaller poaching sample, we obtain very similar results (results available on request).

	(1) log training wage	(2) Within-cell SD of training wages	(3) log wage diff. job-training
log firm density reg.-occ.	0.0422***	0.155***	0.0398***
	(14.86)	(12.24)	(11.68)
Constant	3.394***	0.475***	3.653***
	(45.84)	(11.47)	(30.41)
Observations	196697	83510	195752
R^2	0.275	0.056	0.143
Adjusted R^2	0.275	0.055	0.142

Table 3. Wages and regional competition, baseline sample. t statistics in parentheses. The regression in column 2 contains one observation per training cell (establishment, occupation, year). All estimations include 2-digit occupation fixed effects. Standard errors clustered at region-occupation level (labor market regions, 2-digit occupations). * p<0.10, ** p<0.05, *** p<0.01.

The results of our wage analysis are thus in line with previous research in that non-retained apprenticeship completers are negatively selected on average. Furthermore, we find that training establishments respond to regional competition by setting and differentiating wages strategically. Higher wages (and wage differentiation) during the last training period in regions with higher labor market competition lend additional credibility to our wage-based poaching identification. The patterns of wages found above can be both cause and consequence of apprenticeship completer mobility and poaching. We analyze the training activity of establishments and its possible causes, in the following sections.

[20] See Table 3 in Mühlemann, Ryan, and Wolter (2013).

[21] Both, regional employment and regional employment density are highly correlated with our competition indicator. At 0.41, the correlation coefficient is lower for the former, which we therefore prefer.

6. The impact of regional competition on training, retention, and poaching

The main empirical part of this paper comprises a set of analyses at the establishment level, the level at which decisions on apprentice training, retention, and poaching are made. First, we replicate the analyses of previous papers which found that regional competition has a negative effect on firms' training provision. We then analyze the effect of regional competition on the mobility of apprenticeship completers and on poaching. According to theoretical predictions and empirical findings in the literature (Blatter et al., 2015), we expect that higher labor market competition is associated with a lower retention rate after apprenticeship training and a higher poaching incidence. Furthermore, we analyze whether poaching victims respond to poaching by reducing their training activity. We address each of these questions in a separate subsection.

6.1 Establishments' training provision

First, we investigate training establishments' (victims' and controls') training activity with regard to regional labor market competition. We closely follow the specification of Mühlemann and Wolter (2011) and other related studies. Measuring an establishment's training activity by the (log) number of apprentices trained, we estimate the following specification for establishments' training provision:

$$\begin{aligned} &\ln(apprentices)_{it} \\ &= \beta_0 + \beta_1 comp_{\mathrm{ort}} + \beta_2 \ln L_{it} + \beta_3 share\_midqual_{it} \\ &+ \beta_4 \left(\frac{L_{it} - L_{it-1}}{L_{it-1}}\right) + \beta_5 \ln(med\_wage)_{it} + \beta_6 \ln L_{rt} \\ &+ \beta_7 \ln(empl\_dens)_{rt} + \mu_o + \delta_j + \vartheta_t + \theta_r + u_{it}. \end{aligned} \tag{1}$$

We thus regress the training activity of establishment *i* in year *t* on the degree of competition in its regional occupational labor market, $comp_{\mathrm{ort}}$, measured as the log density (number per square km) of establishments in the same regional occupational labor market.[22]

We include as control variables log labor (full-time employment)[23] and the share of medium-qualified workers, which is a good proxy of the share of employees who have completed an apprenticeship. Both variables are basic controls for the establishment's demand for apprentices. The main insight from Mohrenweiser et al. (2013) is that establishments' training and retention behavior is determined, inter alia, by temporary up- and downturns. It is therefore

[22] Note that the index *o* may represent more than one training occupation per employer.

[23] We only count full-time employees because the data do not contain working time for part-time employees. Note that apprentices are not full-time employees and hence not included in L.

important to control for the establishment's employment growth rate. Further controls include the establishment's log median daily wage of full-time workers and the size (log labor) and density (log of employment per square kilometer) of the labor market region *r*. These controls should capture macro-regional effects on training activity that are not due to regional competition, but to other regional externalities (e.g. the positive and negative effects of agglomeration). We also include fixed effects for training occupations (*o*), industries (*j*), years (*t*), and labor market regions (*r*).[24] Occupation fixed effects in particular are crucial to capture structural differences in supply and demand in the apprenticeship-completer labor market, since apprenticeship training contents are strongly occupation-specific. Ideally, standard errors should be clustered at the level of regional occupational labor markets, the level where competition (the key explanatory variable) varies. This is impossible, however, since there can be more than one training occupation per establishment. We therefore cluster standard errors at the level of regional two-digit industries. Throughout this section, we report results using the narrow poaching sample, since we can perform the core analyses on poaching (section 6.3) only for this sample. Analogous results for the baseline sample, where applicable, are reported as robustness checks in the Appendix.

The estimation results, presented in Table 4, reveal a significant negative effect of regional competition on establishments' training provision. All reported estimations include occupation fixed effects, which previous studies and our descriptive analysis have found to be crucial controls. Industry and year fixed effects are included in column 2. They add little to the overall explanatory power of the model. The same can be said of labor market region fixed effects, which are included in column 3. Our findings are qualitatively in line with previous studies. They can best be compared to Mühlemann and Wolter (2011), who use data from Switzerland, a country whose apprenticeship system is very similar to Germany's. Mühlemann and Wolter (2011) estimate the elasticity of apprentice employment with respect to the density of regional competition at around -0.2, about ten times our estimate. This large difference can be mainly explained by differences between their estimation sample and ours. In particular, 70 percent of their sample establishments do not employ a single apprentice; 99 percent have at most six apprentices. In contrast, our estimation sample contains 100 percent training establishments that are relatively large and have 34 apprentices on average (some establishments even have more than 1,000 apprentices).[25] To analyze the impact of the specific sample we use on the regression

[24] We identify occupations and industries at the two-digit level, respectively.
[25] These numbers deviate from Table A2, which also includes the hiring establishments (raiders and other hirers).

results, we re-run the regressions with our larger baseline sample, see Table A8 in the Appendix. This sample also contains relatively large training firms, but also includes more small training firms than the poaching sample. The baseline sample yields a highly statistically significant elasticity of about -.05. We therefore regard our results as broadly comparable to Mühlemann and Wolter's (2011).

	(1) log apprentices	(2) log apprentices	(3) log apprentices
log estab. density, region-occupation	-.0244** (-2.248)	-.0194* (-1.873)	-.0206** (-2.006)
Log labor (full-time)	.6122*** (65.11)	.6333*** (65.52)	.6372*** (65.47)
Share mid-qual. employees	.2083*** (3.014)	.1649*** (3.127)	.1678*** (3.137)
Employment growth rate	.0655 (1.621)	.0701* (1.751)	.0658* (1.658)
log median daily wage	-.0022 (-.106)	-.0587 (-1.616)	-.0723* (-1.692)
log employment LM region	.0057 (.4059)	8.5e-05 (.0068)	.5086*** (2.729)
log empl. density LM region	-.0137 (-.71)	-.0163 (-.8996)	.0378 (.3634)
Constant	-.9844*** (-5.49)	-.0428 (-.1841)	-6.604*** (-3.098)
Observations	21416	21416	21416
R^2	.703	.724	.735
Adjusted R^2	.702	.723	.732

Table 4: Impact of regional competition on apprenticeship training, poaching sample. t statistics in parentheses. All estimations include 2-digit occupation fixed effects. Columns 2-3 includes 2-digit industry and year fixed effects. Column 3 includes labor market region fixed effects. Standard errors clustered at the region-industry level (labor market regions, 2-digit industries). * p<0.10, ** p<0.05, *** p<0.01.

6.2 Analysis of retention

In a second step, we investigate whether regional competition has a negative effect on the retention of apprenticeship completers by their training establishment. We use the same control variables as in equation (1), plus the log number of apprentices, and consider the number of movers directly after apprenticeship completion as the dependent variable.[26] We thus estimate:

$$\ln(movers)_{it} = \beta_0 + \beta_1 comp_{\mathrm{ort}} + \beta_2 \ln(apprentices)_{it} + controls + \mu_o + \delta_j + \vartheta_t + \theta_r + u_{it}. \quad (2)$$

The estimation results are displayed in Table 5, where the different specifications are analogous to the previous subsection. As expected, we find a positive elasticity for regional competition. Furthermore, the elasticity (in absolute values) is in the same order of magnitude as the negative effect of competition on training. Thus, the negative training effect of regional competition is roughly proportional to its negative retention effect. We run the same regression on the baseline sample (Appendix Table A9), and obtain very similar results.[27]

[26] Since the number of movers is zero for a large number of observations, we actually use ln(movers + 1). This modification has a negligible effect on the results: The correlation between ln(movers) and ln(movers + 1) is 0.994.

[27] One might object that the number of movers (despite the log transformation corrected for zeros) is not an ideal dependent variable for an OLS regression due to the large number of zeros. Thus, we alternatively estimated a Probit model with the dependent variable being a dummy for having at least one mover among all apprenticeship completers (estimation results available on request). These estimations confirm that there is a strong and significant negative relationship between regional competition and retention.

	(1)	(2)	(3)
	log movers	log movers	log movers
log estab. density, region-occupation	.0363***	.0315***	.0306***
	(3.033)	(2.765)	(2.988)
log apprentices	.1689***	.1758***	.1722***
	(11.45)	(11.22)	(11.11)
Log labor (full-time)	-.0578***	-.0655***	-.0668***
	(-6.161)	(-6.611)	(-6.382)
Share mid-qual. employees	-.0168	-.0213*	-.0218*
	(-1.409)	(-1.677)	(-1.71)
Employment growth rate	-.1834***	-.1702***	-.1738***
	(-6.45)	(-5.913)	(-6.056)
log median daily wage	-.006	.054**	.0755***
	(-.4285)	(2.254)	(2.714)
log employment LM region	.025**	.0175*	.1497
	(2.37)	(1.851)	(1.11)
log empl. density LM region	-.0294*	-.0285*	-.1241*
	(-1.799)	(-1.818)	(-1.695)
Constant	-.2164*	-.4956***	-1.799
	(-1.836)	(-2.886)	(-1.139)
Observations	21416	21416	21416
R^2	.18	.196	.224
Adjusted R^2	.177	.191	.214

Table 5: Impact of regional competition on retention of apprenticeship completers, poaching sample. *t* statistics in parentheses. All estimations include 2-digit occupation fixed effects. Columns 2-3 includes 2-digit industry and year fixed effects. Column 3 includes labor market region fixed effects. Standard errors clustered at the region-industry level (labor market regions, 2-digit industries). * p<0.10, ** p<0.05, *** p<0.01.

6.3 Poaching analysis

Our ex-post identification of poaching yields, for each training establishment observation, a number of poaching incidents which can be used to estimate the relationship between an establishment's regional competition and poaching. The poaching variable is non-negative, integer-valued, and small but mostly zero (97 percent). Therefore, one might consider estimating a count data model. However, count data models are inappropriate if the dependent variable contains a large number of zeros. For the choice of an estimator, furthermore, it is crucial to decide whether the data-generating process can be seen as a two-stage decision, and whether the outcome at the second stage (the number of poached apprenticeship completers, given it is positive)

is of interest independently of the first stage (number of poached apprenticeship completers positive versus zero). In the current case, there does not seem to be such a decision process, since of course establishments do not choose to get poached. Instead, the fact whether a training firm experiences poaching or not and the count of poached training completers both represent the same kind of event measured on different scales. Given these preconditions, we decide not to use a count data or hurdle (two-stage) model. Instead, a binary dependent variable indicating whether there is at least one poaching appears as a conservative choice for the dependent variable. We therefore choose to estimate a Probit model.

We follow the approach of Mohrenweiser et al. (2013) and estimate the probability that establishment *i* becomes a poaching victim in year *t* as follows:

$$\mathrm{P}(victim)_{it} = \beta_0 + \beta_1 \ln(apprentices)_{it} + \beta_2 comp_{\mathrm{ort}} + controls + \mu_o + \delta_j + \vartheta_t + \theta_r + u_{it}. \quad (3)$$

As in equation (2), we control for the log number of apprentices, which raises the probability of observing one or more incidents of poaching. The other control variables are as above.[28]

Table 6 provides the average marginal effects (reported as elasticities) from the Probit estimations.[29] A number of observations are dropped from all estimations because some of the included fixed effects perfectly predict the outcome. Across the three different specifications, we find that indeed, regional competition significantly increases training establishments' risk of having at least one apprenticeship completer poached by a competitor. This finding is in line with expectations arising from previous studies,[30] which attribute the negative effect of regional competition on training to an increased risk of poaching. Converted into absolute values, the estimated poaching elasticity of about 0.4 implies that a one percent increase in regional competition increases P(victim) by about 0.01 percentage points, or 38 percent of the sample mean (the share of poaching victims, 2.6 percent). Since the dependent variable represents a probability, we cannot directly compare this estimate to the effects found in the estimations for training (section 6.1) and retention (section 6.2), to assess the importance of poaching (as observed ex-post) for establishments' training decisions. Instead, we investigate the consequences of poaching at the level of individual establishments in the next subsection.

[28] Since the dependent variable is only defined for establishments which fulfill our potential poaching conditions (see section 4.1), we can apply this specification only to the estimation sample of victims and controls (poaching sample) but not to the baseline sample.
[29] We obtain very similar results when estimating a linear probability model (results available on request).
[30] Brunello and Gambarotto (2007), Brunello and De Paola (2008), Mühlemann and Wolter (2011).

We would like to point out that we obtain the same results when measuring competition not for regional occupational labor markets, but regional two-digit industries analogously to the just-cited studies on the consequences of regional competition for training. The estimated elasticity for establishment density in the regional two-digit industry is around 0.39 and highly significant (results available on request). Overall, however, the occupation-based competition measure yields more robust estimates than the industry-based measure.

	(1) Poaching victim	(2) Poaching victim	(3) Poaching victim
log estab. density, region-occupation	.4257*** (3.93)	.3964*** (3.551)	.4333*** (3.607)
log apprentices	.8355*** (6.418)	.8913*** (6.835)	.8978*** (6.907)
Log labor (full-time)	-.5578*** (-5.642)	-.6489*** (-6.233)	-.6675*** (-6.176)
Share mid-qual. employees	-.2224 (-1.513)	-.2605* (-1.807)	-.2486* (-1.769)
Employment growth rate	-2.14*** (-2.809)	-2.112*** (-2.768)	-2.212*** (-2.832)
log median daily wage	.0414 (.2415)	.794** (2.516)	.9971*** (2.815)
log employment LM region	.2026** (2.254)	.1648* (1.873)	1.96 (.7537)
log empl. density LM region	-.4479*** (-3.182)	-.4718*** (-3.301)	-.4351 (-.2433)
Observations	20758	20619	19174
Pseudo R^2	0.084	0.103	0.132
AIC	4815.3	4809.5	4802.1
BIC	5252.0	5642.5	6453.0

Table 6: Impact of regional competition on poaching, poaching sample. *t* statistics in parentheses. Average marginal effects (elasticities) after Probit. All estimations include 2-digit occupation fixed effects. Columns 2-3 includes 2-digit industry and year fixed effects. Column 3 includes labor market region fixed effects. Standard errors clustered at the region-industry level (labor market regions, 2-digit industries). * p<0.10, ** p<0.05, *** p<0.01.

In Appendix C, we present the analogous raiding analysis that is a natural robustness check for the poaching regression. We confirm the positive effect of regional competition on raiding. This finding is not a surprise, however, considering that 70 percent of poached apprenticeship com-

pleters stay within their labor market region (see Table A1), and that training and hiring establishments are likely to have similar occupational profiles. As a consequence, the level of regional competition is similar for training and hiring establishments.

6.4 Training response to poaching

The previous subsections have established that regional competition negatively affects establishments' apprentice training and retention of apprenticeship completers, and that it has a positive effect on the incidence of poaching. However, it remains to be shown whether poaching victims react to poaching by training fewer apprentices. A reduction of training after poaching would suggest a causal link running from regional competition to poaching and further to lower apprentice training of the affected training establishments.

Given the results of Mohrenweiser et al. (2013), whose analysis of the training response we partly replicate in this section, we expect that poaching victims do not adjust their training activities downward in response to past poaching. Figures A3 through A5 in the Appendix display changes of relevant variables during the period from three years before until three years after a poaching event. Figure A3 shows that the share of apprentices is somewhat (but not significantly) higher during the poaching year than in the years before and after. In contrast, the retention rate (Figure A4) and employment (Figure A5) drop significantly in the year of poaching. These patterns suggest that poaching occurs during temporary downturns of the training employer, as found by Mohrenweiser et al. (2013). These downturns force training establishments to lay off workers and not to retain apprenticeship completers. The figures indicate that training establishments refrain from laying off apprentices in general, but they concentrate on laying off apprenticeship completers, instead. Firing apprentices is legally extremely hard once the probationary period (at most four months) is over.[31] In addition, given the low wages apprentices receive, firing them would not reduce labor costs much. Furthermore, apprentices' employment contracts expire on the day the final exam is passed. It is therefore relatively cheap and socially accepted to get rid of apprentices once they have completed their training. As a result, the apprentice share increases slightly in that year. However, poaching does not seem to change establishments' usual training behavior because the retention rate and the apprenticeship share

[31] The Federal Vocational Training Act (*Berufsbildungsgesetz*) contains a number of additional requirements, as compared to the Employment Protection Law (*Kündigungsschutzgesetz*), for laying off apprentices after the probationary period. In particular, apprentices may only be laid off for "important reasons" such as theft, severe misconduct in the workplace, etc.

quickly return to their normal levels, in tandem with the increase in employment, in the years after poaching.

	(1) Share apprentice hires	(2) Share apprentice hires	(3) log growth apprentices	(4) log growth apprentices
L.victim	0.00056	0.000076	-.001	-.0085
	(.8441)	(.1386)	(-.0647)	(-.6463)
L2.victim	-0.0002	-0.00021	-.0139	-.0091
	(-.2876)	(-.3788)	(-.8543)	(-.6669)
L3.victim	-0.00012	0.00016	-.0034	.0059
	(-.1715)	(.2733)	(-.1968)	(.4127)
log apprentices		.0203***		.457***
		(43.69)		(40.23)
Log labor (full-time)		-.023***		-.2687***
		(-23.67)		(-11.5)
Share mid-qual. employees		-.0015***		-.0123*
		(-4.913)		(-1.691)
Employment growth rate		.0212***		.6786***
		(15.77)		(21.05)
log median daily wage		.0014		.002
		(.5857)		(.0355)
log employment LM region		.0158**		-.0919
		(2.105)		(-.5118)
log empl. density LM region		-.009**		-.0816
		(-2.014)		(-.7624)
Constant	.0259***	-.0647	-.0101***	1.606
	(247.2)	(-.7598)	(-4.046)	(.7858)
Observations	6644	6644	6642	6642
R^2	0.00018	.323	0.00014	.309
Adjusted R^2	-.284	.128	-.285	.11

Table 7: Reaction of poaching victims in terms of training activity, poaching sample. t statistics in parentheses. Fixed effects (within-establishment) estimates. Columns 2 and 4 include year fixed effects. * p<0.10, ** p<0.05, *** p<0.01.

We also confirm the multivariate results of Mohrenweiser et al. (2013) that poaching victims do not reduce their training activity after poaching (see Table 7). The dependent variable in these estimations is the share of apprentice hires in all employees (columns 1 and 2) respectively the log growth rate of the stock of apprentices (ln(apprentices in year t) minus ln(apprentices in year t-1); columns 3 and 4). The estimates again suggest that training effort does not change in the years following the poaching incident.

7. Implications for the economics of apprentice training

In our empirical analysis, we confirm previous literature that regional labor market competition is negatively correlated with establishments' apprentice training activity, and positively with apprenticeship completers' job mobility and wages. We complement this finding with new evidence that there is a positive effect of regional competition on actual poaching. With less than three percent of apprenticeship completers being affected, poaching is however a rare and not systematic phenomenon. In addition, poaching does not appear to have any effect on the apprentice training strategy of the victims. Thus, it does not seem to be the actual poaching incidence which discourages firms in competitive regional labor markets from training apprentices. In this section, we add to the few papers that discuss alternative channels that explain the negative training effect of regional competition, in addition to the threat of poaching.

First, not only realized poaching might influence firms' training strategies, but also the perceived threat of poaching. Previous studies have only discussed this threat (or probability) of poaching, which is supposed to increase with regional labor market competition. Naturally, the mere threat of poaching cannot be observed in empirical data, which is why we use an ex-post definition of poaching. We might however assume that actual incidents of poaching influence the perception of training firms about the poaching threat. In this context, the market for apprenticeship completers can be regarded as a contestable market (for a survey of the relevant literature, see Brock, 1983). That is, employers can enter this market at no cost, whereas training establishments have incurred sunk costs for their training investment. The market for apprenticeship completers clearly is contestable in this sense. Overall, thus, the threat of poaching might have a stronger effect on training activity of firms in competitive regions than actual poaching.

The second important factor that differs between regions is the lower general retention rate of apprenticeship completers in more competitive regions, see section 6.2. That is, establishments

in highly competitive regions might train fewer apprentices because they expect to retain a lower share of them, whether due to poaching or other kinds of outflows. A theoretical foundation for this relationship is provided, for example, by the model developed by Smits and Stromback (2001). This model suggests that the incentive of firms to invest in apprenticeship training is positively influenced, inter alia, by the retention rate of apprenticeship completers.[32]

Smits and Stromback's (2001) model furthermore emphasizes the importance of apprentices' productivity (and the degree to which it can be exploited through wage compression) for training profitability. Regarding the importance of regional competition, however, what appears crucial for firms' training decisions is not apprentices' (and apprenticeship completers') productivity per se, but the productivity of apprentices who are retained compared to those who move elsewhere. We do not have data on apprentices' productivity. We can, however, use wage data to learn about the relative productivity of movers and stayers, assuming that training wages reflect productivity. Although movers are generally negatively selected (see section 5 and previous studies), this negative selection might be less pronounced in more competitive regional labor markets, where apprenticeship completers are more likely to find a better job match by moving to a competitor and where retention rates are lower. Previous empirical studies suggest that indeed, there is a positive relationship between regional competition and the individual productivity of moving workers. For instance, Andersson and Thulin (2013) find that regional density increases the mobility of higher qualified workers more than the mobility of lower qualification groups. We therefore investigate whether there are productivity differences between moving apprenticeship completers in more and less competitive regions.

Taking training wages as a productivity signal, we regress wages on a dummy for movers, the regional competition indicator, and an interaction term of the two (see Table 8, column 1).[33] We find that movers earn higher training wages in highly competitive regions than in less competitive regions, suggesting they are less negatively selected where regional competition is stronger. In column 2, we control for the size of the training establishment and the training region, as well as the average wage in the training region.[34] Establishment size in particular is an important driver of monopsony power and hence, wages (Manning, 2011). These additional

[32] The profit function from apprenticeship training in Smits and Stromback (2001) is defined as $\Pi = -w_1 - c(h) + (1-q)(h-w_2)$, with Π profits, w_1 apprentice earnings, c apprenticeship costs, q retention probability, h productivity of apprentices, and w_2 skilled wage. A broader discussion of the profitability of apprenticeships, focusing on Germany and Switzerland, is provided by Mühlemann and Wolter (2014), who emphasize the role of national institutions and firm characteristics, rather than the regional environment.

[33] We use the baseline sample because the poaching variable is not needed here. We obtain qualitatively the same results using the poaching sample, see Table A10 in the Appendix.

[34] The average wage in the training region is defined as the average of establishment-level median wages.

controls leave our results almost unchanged. A major concern in the literature on wages and regional labor market competition is the fact that living costs, employer characteristics and labor market competition may be correlated and affect wages jointly (Boal and Ransom, 1997). Note, however, that this problem applies to agglomeration effects (which we control for by including region-level employment and wages) but not necessarily to regional competition. Nevertheless, to ensure that our results are not driven by such correlations, we exclude interregional movers in column 3, which leads to a minor sample restriction given that most employer changes are intra-regional. Again, this leaves the estimates mostly unchanged.

	(1) log training wage	(2) log training wage	(3) log training wage
Mover	-0.0226*** (-4.07)	-0.0183*** (-3.23)	-0.0136** (-2.11)
log firm density reg.-occ.	0.0414*** (14.99)	0.0114*** (4.25)	0.0115*** (4.37)
Mover*log firm density reg.-occ.	0.0105*** (2.61)	0.00854** (2.25)	0.0164*** (3.80)
log full-time employment, training estab.		0.0436*** (17.28)	0.0441*** (17.89)
log employment, training region		-0.0144*** (-3.06)	-0.0143*** (-3.03)
log avg. wage, training region		0.348*** (9.16)	0.346*** (9.03)
Constant	3.392*** (45.79)	1.849*** (10.84)	1.855*** (10.91)
Observations	196697	196500	190349
R^2	0.276	0.350	0.350
Adjusted R^2	0.276	0.350	0.349

Table 8. Training wage differences between retained and moving apprenticeship completers by regional competition, baseline sample. t statistics in parentheses. All estimations include 2-digit occupation fixed effects. Standard errors clustered at region-occupation level (labor market region of training establishment, 2-digit occupations). Column 3 excludes interregional movers. * p<0.10, ** p<0.05, *** p<0.01.

We also consider apprenticeship completers' training wages relative to the mean in their training cell in Table 9.[35] The results also indicate that movers are less negatively selected from among their peers if their training establishment is located in a highly competitive region. The

[35] Analogous regression results for the poaching sample in Appendix Table A11.

effect is only marginally significant (column 1) and drops below conventional significance levels if inter-regional movers are excluded as a robustness check (column 2).[36] Still, the estimates point in the same direction as those for the absolute training wage and therefore do not invalidate our interpretation that movers in highly competitive regions are relatively favorably selected. Our findings therefore imply that a relatively large number and abler apprenticeship completers can be hired by external firms in more competitive regions, which is a disincentive to train own apprentices. Similar to previous studies (Mühlemann, Ryan, and Wolter, 2013), our findings also suggest that the higher training costs implied by higher apprentice wages, which are largely sunk costs if apprentices move after training, deter employers in competitive regions from training.

	(1) Training wage rel. to cell mean	(2) Training wage rel. to cell mean
Mover	-0.203***	-0.223***
	(-2.96)	(-2.76)
log firm density reg.-occ.	-0.00254	0.00250
	(-0.97)	(1.00)
Mover*log firm density reg.-occ.	0.0467*	0.0288
	(1.68)	(0.97)
Constant	-0.00694	0.00684
	(-0.97)	(0.99)
Observations	196697	190529
R^2	0.000	0.000
Adjusted R^2	-0.000	-0.000

Table 9: Training wage position, differences between retained and moving apprenticeship completers by regional competition, baseline sample. t statistics in parentheses. All estimations include 2-digit occupation fixed effects. Standard errors clustered at region-occupation level (labor market region of training establishment, 2-digit occupations). Column 2 excludes interregional movers. * p<0.10, ** p<0.05, *** p<0.01.

Additional to the relative quality and wage costs of apprentices, firms' training decisions are likely influenced by the wage costs of young skilled workers. An important topic discussed in the literature is the negative impact of fewness within regional (occupational) labor markets on wages of trained employees (Boal and Ransom, 1997; Manning, 2011; Mühlemann et al., 2013). Monopsony power is mainly measured within regions if employees' mobility costs are high, and within occupations if there are strong demarcation lines between occupations. Cases in

[36] Due to the definition of the relative training wage (wage position within training the establishment), we do not include establishment- or region-level controls.

point are remote mining towns, nurses, and teachers (Boal and Ransom, 1997; Benson, 2013). Regional and occupational barriers are well documented for the labor market of apprenticeship completers (Harhoff and Kane, 1997; Acemoglu and Pischke, 1998; Mühlemann et al., 2013). Many studies relate regional monopsony power to incentives to train and they concentrate on wage differences between unskilled and skilled employees (Stevens, 1994; Acemoglu and Pischke, 1998). Mühlemann et al. (2013) for example show that there is a positive effect of the number of regional employers on the wages of skilled employees and apprentices, an effect that is absent for unskilled employees. Analogously, wage differences between skilled and unskilled employees increase with the number of firms in a region. In contrast, the difference between skilled and apprentice wages is not affected.

From the perspective of firms that have to decide whether to train themselves instead of hiring apprenticeship completers (mainly) from their regional occupational labor market, however, the wage difference between externally hired and own apprenticeship completers should be more important than the wage difference between trained and untrained workers. We therefore compare the entry wages of movers and stayers, net of their previous training wages (also compare Table 3), in the context of regional competition. Subtracting the training wage from the skilled entry wage has the advantage that training wages control for productivity during training, thus yielding a wage indicator corrected for individual productivity. Regression results are reported in Table 10.[37] Again, the main regressor of interest is the interaction between the mover dummy and regional competition. We find a significant negative coefficient for this term, meaning that movers in highly competitive regions obtain lower wage increases between training and their first skilled job than movers in less competitive regions. This finding is robust across different specifications: In column 2, we include the size of the hiring establishment and its region, as well as the regional wage level. In column 3, we include the same variables of the training establishments, since the dependent variable is determined in both the training and hiring establishments. Finally, in column 4, we again restrict the sample to stayers and intra-regional movers, to rule out endogeneity bias from inter-regional differences in costs of living and wages.[38] At first sight, our results appear to be at odds with our earlier finding that movers are a relatively good selection in competitive regions. Note, however, that the wage difference be-

[37] See Table A12 in the Appendix for results using the poaching sample.

[38] Obviously, the training and hiring region are the same in this subsample. We therefore omit the training region controls in column 4.

tween training and skilled work already accounts for differences in individual quality. We therefore argue that movers' effective wage costs as skilled workers (taking into account their higher productivity as apprentices) are relatively low in competitive regions.

	(1) log wage diff. job-training	(2) log wage diff. job-training	(3) log wage diff. job-training	(4) log wage diff. job-training
Mover	-0.0868***	0.00209	-0.0147	0.00468
	(-7.26)	(0.17)	(-1.43)	(0.35)
log firm density reg.-occ.	0.0418***	0.00106	0.000891	-0.000418
	(12.36)	(0.34)	(0.28)	(-0.13)
Mover*log firm density reg.-occ.	-0.0221***	-0.0222***	-0.0211***	-0.0291***
	(-3.98)	(-3.79)	(-3.67)	(-4.22)
log full-time employment, hiring estab.		0.0694***	0.0557***	0.0700***
		(23.20)	(12.06)	(22.93)
log employment, hiring region		-0.0141**	-0.00933	-0.0128**
		(-2.57)	(-1.02)	(-2.28)
log avg. wage, hiring region		0.394***	0.475***	0.388***
		(9.12)	(4.59)	(8.94)
log full-time employment, training estab.			0.0152***	
			(3.06)	
log employment, training region			-0.00541	
			(-0.61)	
log avg. wage, training region			-0.0852	
			(-0.87)	
Constant	3.658***	1.806***	1.826***	1.809***
	(30.47)	(8.07)	(8.05)	(8.01)
Observations	195752	195539	195495	189469
R^2	0.145	0.208	0.209	0.210
Adjusted R^2	0.145	0.208	0.208	0.210

Table 10: Wage increase between training and skilled job, differences between retained and moving apprenticeship completers by regional competition, baseline sample. t statistics in parentheses. All estimations include 2-digit occupation fixed effects. Standard errors clustered at region-occupation level (labor market region of hiring establishment, 2-digit occupations). Column 4 excludes interregional movers. * p<0.10, ** p<0.05, *** p<0.01.

Our findings on wage differences between the last training period and the first wage as skilled employee also imply that higher regional labor market competition is associated with less opportunities for training firms to reduce skilled entry wages for their apprenticeship completers. Our findings finally reflect a recurring topic in regional economics – that agglomerations or "thick" regional labor markets allow for better firm-worker matching (Manning, 2011). Especially regarding apprenticeship completers, who are regionally not very mobile, the better supply of apprenticeship completers (from other firms) in dense regions may be a potent reason not to invest as much in own training. This interpretation receives further support from the literature: Blatter et al. (2015) investigate the costs of hiring skilled workers in Switzerland. They find that training activity and the retention of own apprenticeship completers positively depend on external hiring costs. Our data do not contain direct hiring costs and therefore we cannot investigate their effect on training and hiring decisions.[39] We might argue, however, that the "pure hiring costs" beyond the wage offer necessary to attract skilled employees, such as advertising or the hiring procedure itself, are probably lower in dense regional labor markets, because it is not necessary to look for candidates working and living in another regional labor market. Overcoming mobility barriers in order to attract new employees from other labor market regions seems to be especially costly for apprenticeship completers in Germany, as indicated by their low level of inter-regional mobility. Mühlemann et al. (2015) in addition find that recruitment costs in Germany decrease with the regional supply of apprenticeship completers. The last reason for lower hiring costs in agglomerations is the higher average quality of job candidates, meaning that less "lemons" have to be screened before finding a good match (Blatter et al., 2015).

Overall, we therefore conclude that the negative effect of regional competition on apprentice training works not only through the negative agglomeration effect of an increased poaching risk. It also works through the better availability of externally trained apprenticeship completers, a commonly positively perceived agglomeration effect. Other important aspects are a better selection, higher training costs, and relatively low labor and hiring costs of available apprenticeship completers. These additional reasons for lower training in more competitive regions have been discussed mainly in theoretical contributions so far. The few empirical contributions concentrated on one of the mechanisms analyzed here. Our paper therefore presents the first

[39] Another obstacle to replicate the Blatter et al. (2015) study is that we do not observe external hiring establishments' (raiders' and other hirers') own apprentice training in the same detail as for the sampled training establishments (victims and controls). A full analysis of the training behaviour of raiding firms would require a larger and even more complex data base. Future work might pursue this kind of analysis.

systematic empirical analysis of potential transmission channels between regional competition and training investments. It finds evidence for all the channels proposed in the literature, but reveals that poaching externalities are relatively unimportant.

8. Conclusions

We investigate whether poaching of apprenticeship completers in Germany is related to the regional labor market competition which training establishments face. We aim to contribute to a growing literature which suggests that regional labor market competition deters firms' training activity and claims that this is a consequence of firms' fear of having trained workers poached by competitors. Yet, none of these studies addresses the incidence of poaching directly. We apply an ex-post identification of poaching to address this gap in the empirical literature. Therein, we exploit the institutional design of the German apprenticeship system, which features training that is transferable between employers active in the same occupational labor market. In addition, individual trained workers' quality can be credibly shown by graded certificates.

Similar to previous studies, we find that the relationship between regional competition and German establishments' apprentice training efforts is significantly negative. Also in line with previous evidence, we find that regional competition decreases the retention of apprenticeship completers by their training firms. We finally find that poaching is positively associated with regional labor market competition. Endogeneity, in particular in the form of reverse causality, is unlikely to be a major problem in our estimations, as regional levels of competition are unlikely to be affected by the observed incidents of poaching in a labor market region. We also show that firms in competitive regions are more likely to "raid" apprenticeship completers (commit poaching). The last finding largely reflects the fact that more than 70 percent of apprenticeship completers stay in the same labor market region when they change employers, which makes regions a suitable dimension for the analysis of competition in the first place.

However, we do not find poaching events to have any effect on victims' subsequent training behavior. We therefore seek to provide alternative explanations for the negative training effect of regional competition. We argue that certainly the (unmeasurable) threat of poaching might play a role. Yet more important might be regional differences that apply to all employer movers instead of differences that only concern the tiny group of poached apprenticeship completers. We find analogously to mainly theoretical papers that the retention rate is structurally lower in

highly competitive labor market regions. Besides the higher availability of apprenticeship completers willing to move to another employer, this employee group is less adversely selected in more competitive regions. As more productive apprentices are more expensive, personnel costs of training firms are higher in competitive regions. Finally, hiring and (entry) wage costs of apprenticeship completers trained elsewhere are lower when we take into account their higher productivity. These differences all reduce the attractiveness of own training efforts in regions with a strong labor market competition.

We therefore conclude that it is not actual poaching of apprenticeship completers that drives the lower training rates in highly competitive regional labor markets. Instead, the better availability and quality of apprenticeship completers who are willing to change their employer directly after training, and the lower hiring and wage costs of apprenticeship completers who move to another employer, seem to be more important.

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Appendix A

A: Poaching sample	Mean	SD	Min	Max	N
Stayer	0.925	0.264	0.000	1.000	134602
Interregional mover	0.212	0.408	0.000	1.000	10127
Poached mover	0.084	0.278	0.000	1.000	10127
Interregional poaching	0.299	0.458	0.000	1.000	855
Age	21.479	2.010	17.000	52.000	134602
Female	0.338	0.473	0.000	1.000	134602
Duration of apprenticeship	1068.275	159.715	700.000	1492.000	134602
Training wage	32.923	9.030	8.915	82.053	134602
First-job wage	80.274	17.706	10.406	490.424	134602
Wage difference job - training	47.350	17.279	-32.538	461.585	134602
Training wage rel. to cell mean	-0.000	3.856	-41.135	43.072	134602
B: Baseline sample					
Stayer	0.886	0.318	0.000	1.000	196697
Interregional mover	0.275	0.447	0.000	1.000	22415
Age	21.535	2.109	17.000	53.000	196697
Female	0.340	0.474	0.000	1.000	196697
Duration of apprenticeship	1068.327	158.556	700.000	1492.000	196697
Training wage	34.126	10.241	8.823	96.593	196697
First-job wage	82.799	21.425	10.011	482.386	196697
Wage difference job - training	48.673	19.161	-40.956	447.772	196697
Training wage rel. to cell mean	0.000	3.648	-48.575	48.071	196697

Table A1. Summary statistics for apprenticeship completers.

Establishments (poaching sample)	Mean	SD	Min	Max	N
Apprentices	27.966	64.855	0.000	1944.000	27039
Apprenticeship completers	6.285	9.736	1.000	356.000	21416
Movers	0.473	2.338	0.000	73.000	21416
Poachings	0.040	0.383	0.000	22.000	21416
Ext. appr. completer hires	1.754	2.986	1.000	65.000	5623
Raidings	0.145	0.615	0.000	18.000	5623
log estab. density, region-occupation	-0.823	1.641	-7.375	3.315	27039
log estab. density, region-industry	-2.445	1.620	-8.417	1.959	27039
Employees	629.158	1889.555	3.000	53391.000	27039
Full-time employment	523.681	1675.053	1.000	49438.000	27039
Share mid-qual. employees	0.815	0.307	-7.000	20.000	27039
Employment growth rate	0.026	0.135	-0.317	1.313	27039
Median full-time daily wage	103.747	26.891	18.079	187.133	27039
East Germany	0.157	0.364	0.000	1.000	27039
log employment LM region	12.676	0.913	9.875	14.201	27039
log empl. density LM region	4.697	0.779	2.540	6.679	27039
Share apprentice hires	0.027	0.021	0.000	0.226	21416

Table A2. Summary statistics for establishments (poaching sample). Apprenticeship completers, movers and poached employees only defined for training establishments. External apprenticeship completer hires and raided employees only defined for external hiring establishments.

Establishments (baseline sample)	**Mean**	**SD**	**Min**	**Max**	**N**
Apprentices	15.668	45.178	0.000	1944.000	72402
Apprenticeship completers	3.373	7.011	1.000	367.000	58632
Movers	0.401	2.299	0.000	171.000	58632
Ext. appr. completer hires	1.534	3.454	1.000	192.000	13770
log estab. density, region-occupation	-0.737	1.572	-7.375	3.315	72402
log estab. density, region-industry	-1.964	1.708	-8.625	2.129	72402
Employees	336.062	1274.026	1.000	53391.000	72402
Full-time employment	275.059	1121.906	0.000	49438.000	72402
Share mid-qual. employees	0.830	0.394	-16.000	20.000	72402
Employment growth rate	0.038	0.265	-1.000	6.000	72402
Median full-time daily wage	84.696	27.805	1.430	245.400	72136
East Germany	0.201	0.400	0.000	1.000	72402
log employment LM region	12.647	0.934	9.875	14.201	72402
log empl. density LM region	4.646	0.788	2.540	6.679	72402

Table A3. Summary statistics for establishments (baseline sample). Apprenticeship completers and movers only defined for training establishments. External apprenticeship completer hires only defined for external hiring establishments.

	(1) log training wage	(2) log training wage	(3) log training wage	(4) Training wage rel. to cell mean
Mover	-0.00630	-0.00819	-0.0104	-0.256**
	(-0.62)	(-0.84)	(-1.05)	(-2.24)
log full-time employment, estab.		0.0401***	0.0359***	
		(11.10)	(9.13)	
log empl. density, region			0.0242***	
			(4.04)	
Constant	3.377***	3.115***	3.017***	0.00511
	(85.76)	(57.05)	(53.11)	(1.08)
Observations	134602	134602	134602	134602
R^2	0.204	0.247	0.252	0.000
Adjusted R^2	0.204	0.247	0.252	-0.000

Table A4: Training wage differences between apprenticeship completers who move and stay with their training employers, poaching sample. *t* statistics in parentheses. All estimations include 2-digit occupation fixed effects. Standard errors clustered at region-occupation level (labor market regions, 2-digit occupations). * p<0.10, ** p<0.05, *** p<0.01.

	(1) log training wage	(2) log training wage	(3) log training wage
log firm density reg.-occ.	0.0422***	0.0238***	0.0208***
	(14.86)	(8.47)	(8.05)
log full-time employment		0.0467***	0.0464***
		(19.76)	(19.17)
log employment, region			0.00682
			(1.44)
Constant	3.394***	3.200***	3.105***
	(45.84)	(44.50)	(33.20)
Observations	196697	196500	196500
R^2	0.275	0.338	0.338
Adjusted R^2	0.275	0.337	0.338

Table A5: Training wages by regional labor competition, baseline sample. *t* statistics in parentheses. Reduction of observation number in column 2 due to establishments with zero full-time employees. All estimations include 2-digit occupation fixed effects. Standard errors clustered at region-occupation level (labor market regions, 2-digit occupations). * p<0.10, ** p<0.05, *** p<0.01.

	(1) Within-cell SD of training wages	(2) Within-cell SD of training wages	(3) Within-cell SD of training wages
log firm density reg.-occ.	0.155***	0.0558***	0.0211
	(12.24)	(5.01)	(1.60)
log full-time employment		0.329***	0.329***
		(27.12)	(27.35)
log employment, region			0.0834***
			(4.34)
Constant	0.475***	-0.793***	-1.960***
	(11.47)	(-6.97)	(-6.23)
Observations	83510	83314	83314
R^2	0.056	0.100	0.101
Adjusted R^2	0.055	0.099	0.100

Table A6: Standard deviations of training wages in cell by regional labor competition, baseline sample. t statistics in parentheses. Reduction of observation number in column 2 due to establishments with zero full-time employees. All estimations include 2-digit occupation fixed effects. Standard errors clustered at region-occupation level (labor market regions, 2-digit occupations). * p<0.10, ** p<0.05, *** p<0.01.

	(1) log wage diff. job-training	(2) log wage diff. job-training	(3) log wage diff. job-training
log firm density reg.-occ.	0.0398*** (11.68)	0.0128*** (4.09)	0.00806*** (2.72)
log full-time employment		0.0715*** (23.26)	0.0711*** (22.90)
log employment, region			0.0115** (2.01)
Constant	3.653*** (30.41)	3.359*** (27.97)	3.198*** (22.49)
Observations	195752	195539	195539
R^2	0.143	0.202	0.202
Adjusted R^2	0.142	0.201	0.202

Table A7: Differences between first skilled wages and training wages by labor market competition, baseline sample. t statistics in parentheses. Reduction of observation number in column 2 due to establishments with zero full-time employees. All estimations include 2-digit occupation fixed effects. Standard errors clustered at region-occupation level (labor market regions, 2-digit occupations). * p<0.10, ** p<0.05, *** p<0.01.

	(1) log apprentices	(2) log apprentices	(3) log apprentices
log estab. density, region-occupation	-.0433*** (-5.838)	-.0496*** (-7.043)	-.0455*** (-6.502)
Log labor (full-time)	.5487*** (82.59)	.5703*** (80.88)	.5709*** (79.74)
Share mid-qual. employees	.1398*** (6.29)	.1219*** (6.199)	.1241*** (6.161)
Employment growth rate	.0898*** (4.391)	.0874*** (4.257)	.0864*** (4.224)
log median daily wage	-5.4e-04 (-.0238)	.0149 (.6468)	.0035 (.1368)
log employment LM region	-.007 (-.616)	-.0121 (-1.283)	.374*** (2.669)
log empl. density LM region	.0189 (1.322)	.0192 (1.471)	.0024 (.0302)
Constant	-.7948*** (-5.705)	-.0101 (-.0478)	-4.638*** (-2.988)
Observations	58436	58436	58436
R^2	.696	.711	.716
Adjusted R^2	.695	.71	.714

Table A8: Impact of regional competition on apprenticeship training, baseline sample. t statistics in parentheses. All estimations include 2-digit occupation fixed effects. Columns 2-3 includes 2-digit industry and year fixed effects. Column 3 includes labor market region fixed effects. Standard errors clustered at the region-industry level (labor market regions, 2-digit industries). * p<0.10, ** p<0.05, *** p<0.01.

	(1) log movers	(2) log movers	(3) log movers
log estab. density, region-occupation	.0238*** (3.784)	.0189*** (3.222)	.0198*** (3.4)
log apprentices	.1161*** (18.04)	.1139*** (17.42)	.1142*** (17.69)
Log labor (full-time)	-.0421*** (-10.98)	-.0393*** (-10.65)	-.0406*** (-10.87)
Share mid-qual. employees	.0013 (.359)	-6.4e-04 (-.1702)	-.0026 (-.6758)
Employment growth rate	-.1821*** (-15.02)	-.1846*** (-15.57)	-.1804*** (-15.22)
log median daily wage	.0424*** (3.516)	.0436*** (3.959)	.061*** (5.018)
log employment LM region	.0261*** (4.368)	.0218*** (4.09)	.138* (1.72)
log empl. density LM region	-.0308*** (-3.647)	-.0266*** (-3.373)	-.0812 (-1.548)
Constant	-.3745*** (-5.04)	-.1362 (-1.248)	-1.422 (-1.587)
Observations	58436	58436	58436
R^2	.168	.181	.189
Adjusted R^2	.167	.179	.186

Table A9. Impact of regional competition on retention, baseline sample. t statistics in parentheses. All estimations include 2-digit occupation fixed effects. Columns 2-3 includes 2-digit industry and year fixed effects. Column 3 includes labor market region fixed effects. Standard errors clustered at the region-industry level (labor market regions, 2-digit industries). * p<0.10, ** p<0.05, *** p<0.01.

	(1) log training wage	(2) log training wage	(3) log training wage
Mover	0.00146	-0.00304	-0.00203
	(0.17)	(-0.37)	(-0.21)
log firm density reg.-occ.	0.0287***	0.00252	0.00280
	(9.21)	(0.80)	(0.90)
Mover*log firm density reg.-occ.	0.0154**	0.0154**	0.0218***
	(2.19)	(2.38)	(3.10)
log full-time employment, training estab.		0.0302***	0.0301***
		(6.83)	(7.00)
log employment, training region		-0.0219***	-0.0217***
		(-3.68)	(-3.72)
log avg. wage, training region		0.474***	0.473***
		(10.46)	(10.50)
Constant	3.370***	1.393***	1.393***
	(96.86)	(6.96)	(7.06)
Observations	134602	134482	132341
R^2	0.220	0.279	0.279
Adjusted R^2	0.220	0.279	0.278

Table A10: Training wage differences between retained and moving apprenticeship completers by regional competition, poaching sample. t statistics in parentheses. All estimations include 2-digit occupation fixed effects. Standard errors clustered at region-occupation level (labor market region of training establishment, 2-digit occupations). Column 3 excludes interregional movers. * p<0.10, ** p<0.05, *** p<0.01.

	(1) Training wage rel. to cell mean	(2) Training wage rel. to cell mean
Mover	-0.215*	-0.239*
	(-1.95)	(-1.92)
log firm density reg.-occ.	-0.00168	0.00393
	(-0.65)	(1.40)
Mover*log firm density reg.-occ.	0.0577	0.0405
	(1.27)	(0.88)
Constant	0.00339	0.00296
	(0.92)	(0.85)
Observations	134602	132460
R^2	0.000	0.000
Adjusted R^2	-0.000	-0.000

Table A11: Training wage position, differences between retained and moving apprenticeship completers by regional competition, poaching sample. t statistics in parentheses. All estimations include 2-digit occupation fixed effects. Standard errors clustered at region-occupation level (labor market region of training establishment, 2-digit occupations). Column 2 excludes interregional movers. * p<0.10, ** p<0.05, *** p<0.01.

	(1) log wage diff. job-training	(2) log wage diff. job-training	(3) log wage diff. job-training	(4) log wage diff. job-training
Mover	-0.0590** (-2.57)	0.0226 (0.96)	0.0159 (0.88)	0.0190 (0.79)
log firm density reg.-occ.	0.0298*** (7.31)	-0.00841* (-1.96)	-0.00842* (-1.93)	-0.00922** (-2.19)
Mover*log firm density reg.-occ.	-0.0224** (-2.53)	-0.0288*** (-3.26)	-0.0302*** (-3.22)	-0.0380*** (-3.57)
log full-time employment, hiring estab.		0.0574*** (11.76)	0.0534*** (6.34)	0.0577*** (11.59)
log employment, hiring region		-0.0240*** (-3.26)	0.00159 (0.08)	-0.0234*** (-3.13)
log avg. wage, hiring region		0.542*** (9.29)	0.477** (2.20)	0.540*** (9.26)
log full-time employment, training estab.			0.00452 (0.46)	
log employment, training region			-0.0260 (-1.32)	
log avg. wage, training region			0.0640 (0.31)	
Constant	3.734*** (31.97)	1.305*** (4.81)	1.313*** (4.81)	1.304*** (4.81)
Observations	134102	133976	133975	131863
R^2	0.133	0.179	0.179	0.181
Adjusted R^2	0.132	0.179	0.179	0.180

Table A12: Wage increase between training and skilled job, differences between retained and moving apprenticeship completers by regional competition, poaching sample. t statistics in parentheses. All estimations include 2-digit occupation fixed effects. Standard errors clustered at region-occupation level (labor market region of hiring establishment, 2-digit occupations). Column 4 excludes interregional movers. * p<0.10, ** p<0.05, *** p<0.01.

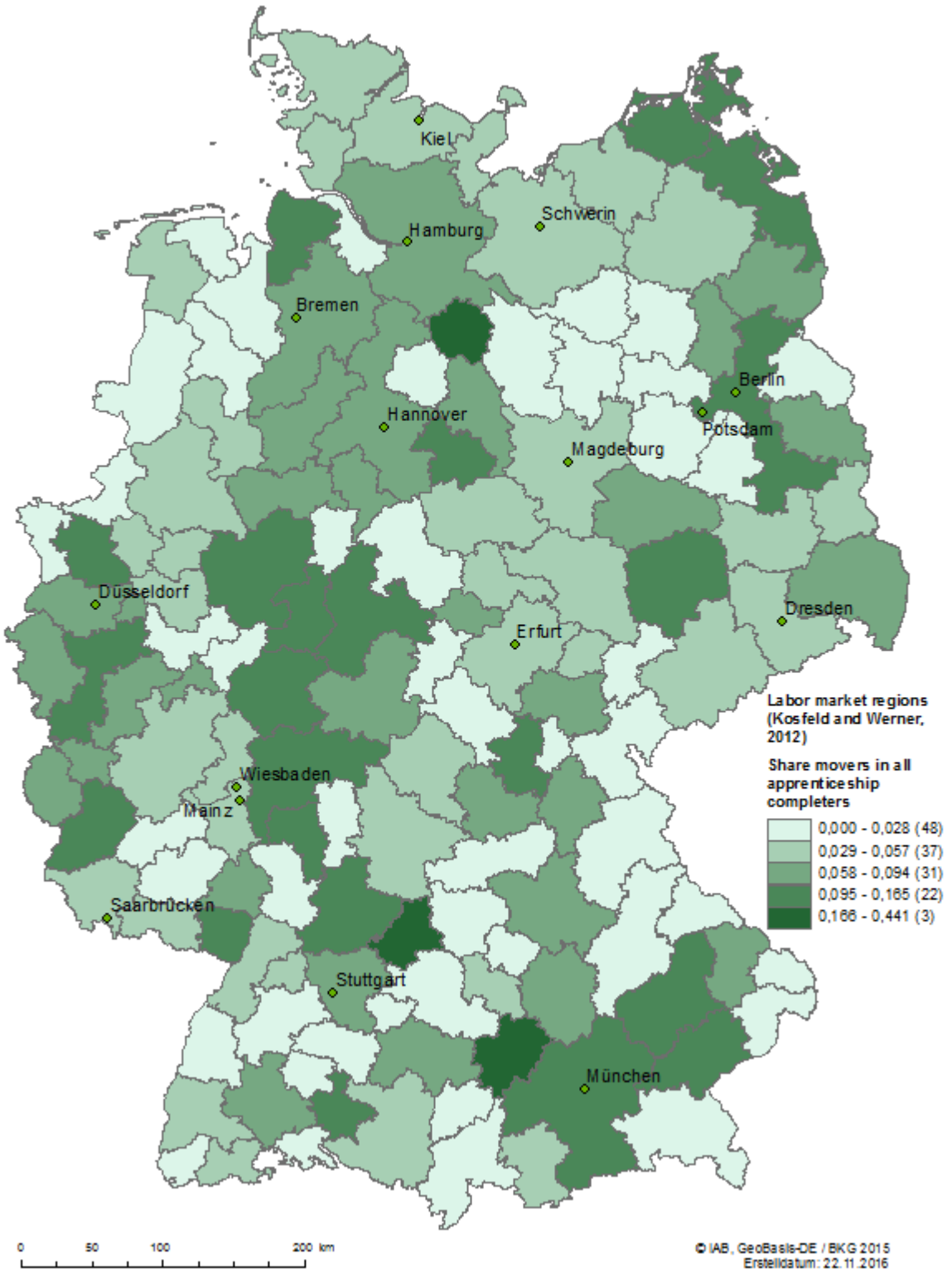

Figure A1: Share of movers in all apprenticeship completers in the estimation sample (1999-2010).

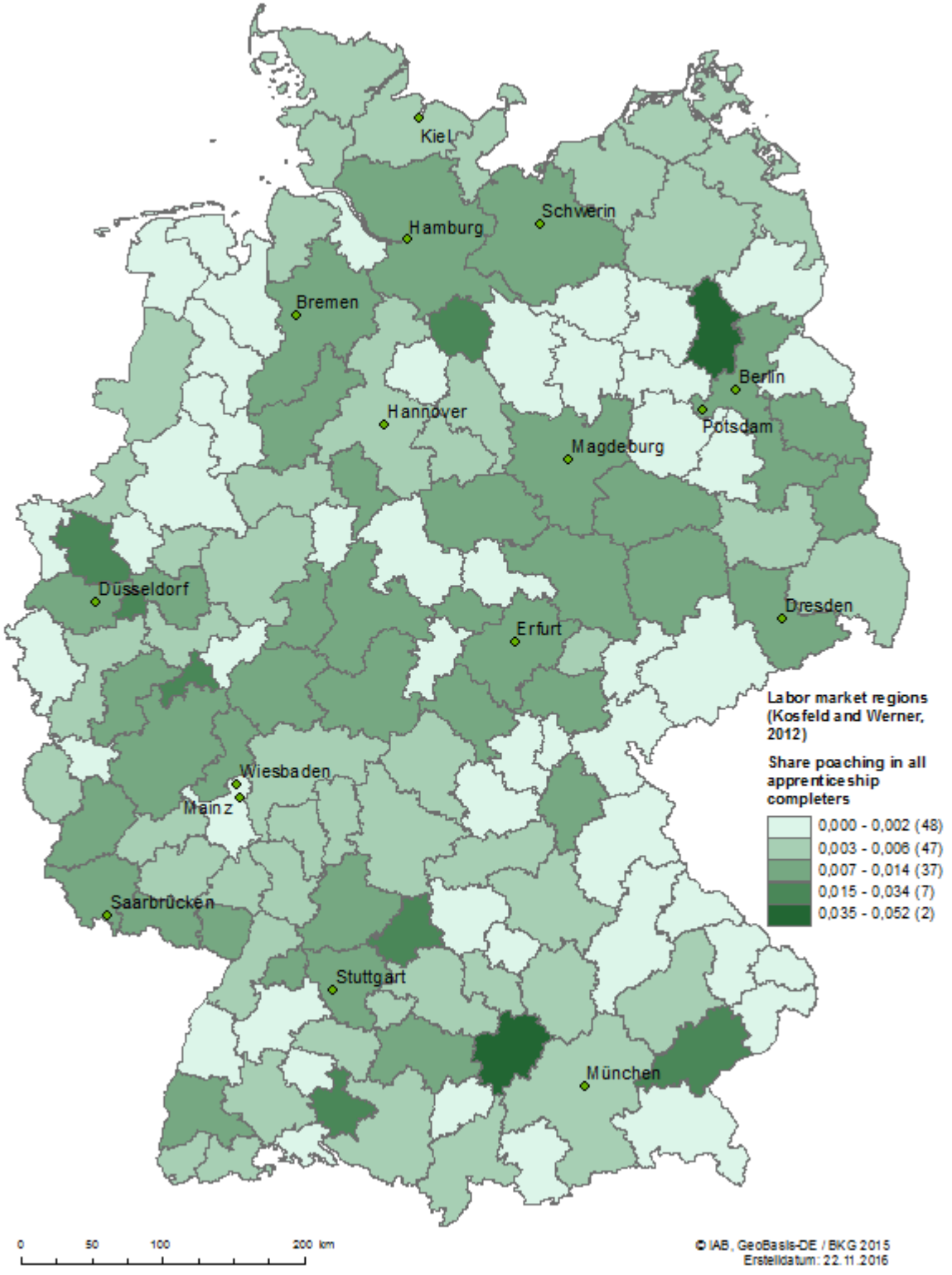

Figure A2: Share of poachings in all apprenticeship completers in the estimation sample (1999-2010).

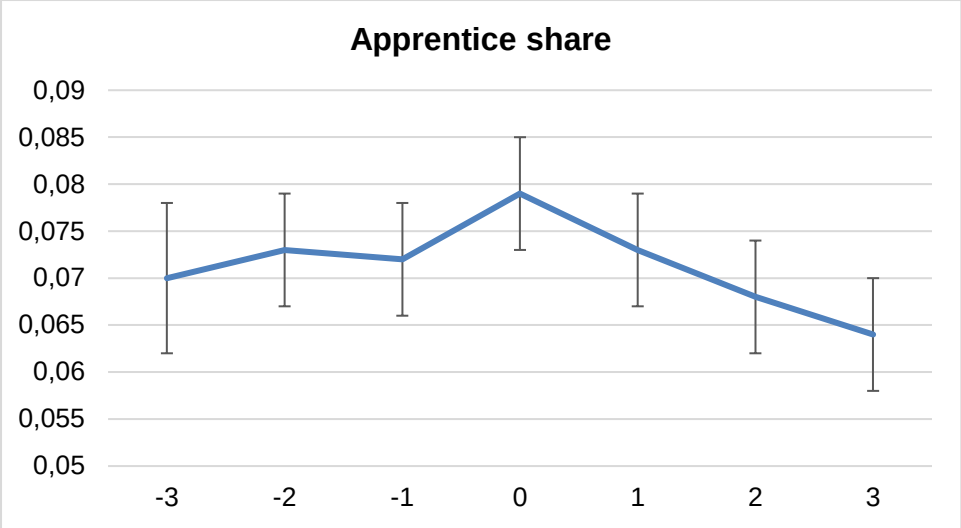

Figure A3. Apprentice share by year for one-time poaching victims (0 = year of poaching). Means and 95% confidence intervals. Unbalanced panel of 317 poaching victims (N = 1,280).

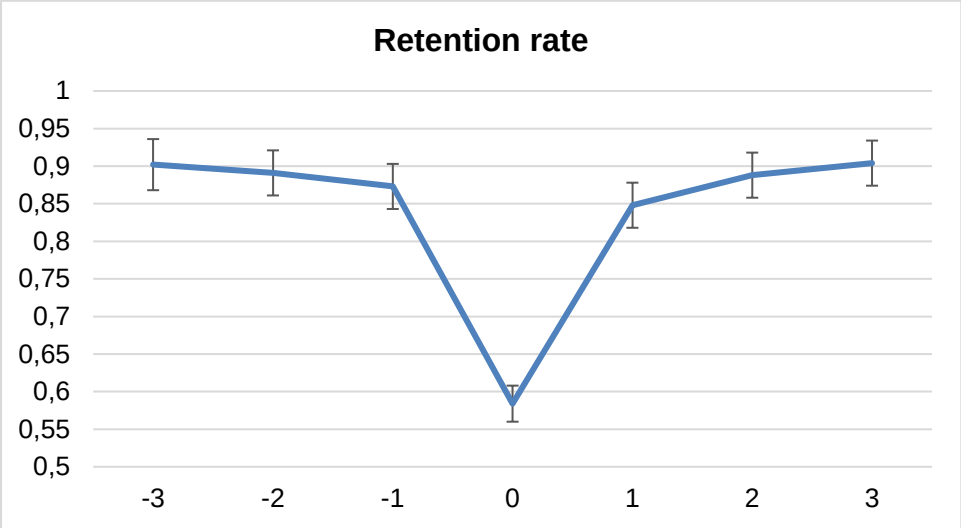

Figure A4. Retention rate by year for one-time poaching victims (0 = year of poaching). Means and 95% confidence intervals. Unbalanced panel of 317 poaching victims (N = 1,280).

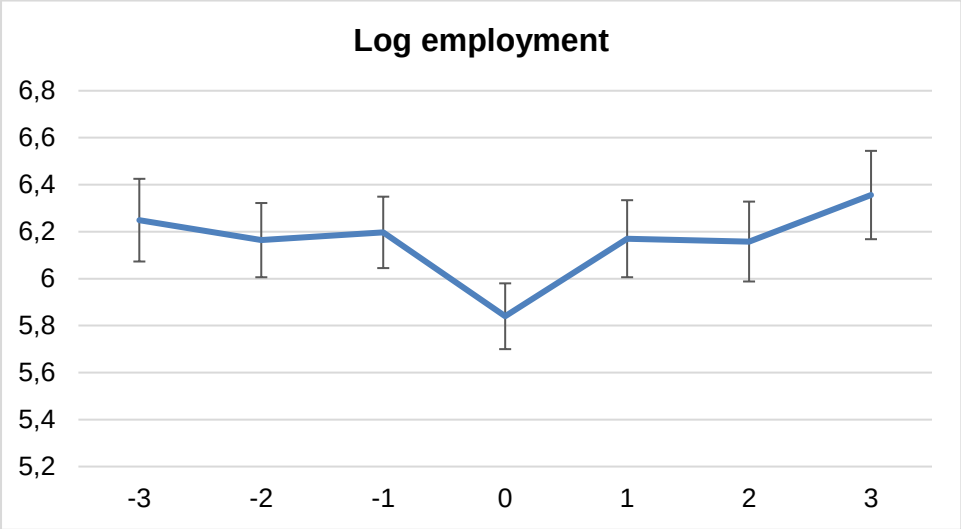

Figure A5. Log employment by year for one-time poaching victims (0 = year of poaching). Means and 95% confidence intervals. Unbalanced panel of 317 poaching victims (N = 1,280).

Appendix B

Spurious worker mobility

To rule out spurious job moves of apprenticeship completers (mainly establishment changes within a firm), we use a procedure developed by Schäffler (2014). This procedure identifies which establishments most likely belong to the same firm and excludes worker flows between such establishments because they should not be subject to "normal" employer competition.[40] The assignment of establishment IDs in the IAB data also implies that the entry or exit of IDs need not reflect true openings or closures of establishments, but may also indicate changes of owner, acquisitions, spin-offs, restructurings, or other events in which worker transitions between establishment IDs are probably due to decisions taken at the firm or establishment level, rather than the worker level. Therefore, also such worker transitions do not reflect true worker mobility between competing employers. We use a file produced by Hethey and Schmieder (2010) which contains, for all establishment IDs and the years of the first and last appearance of that ID, the likely cause of its (dis-)appearance. We exclude moves between establishment IDs that are likely due to spin-offs, closures or acquisitions of the training establishment, or other establishment ID changes in completers' employment records that most likely do not reflect real worker mobility. In a further data cleaning step, we also drop remaining clusters of apprenticeship completers' establishment ID changes that appear to be too large to be considered as individual mobility decisions by the workers.

[40] The method proposed by Schäffler (2014) requires the use of de-anonymized data: Establishments' firm affiliation is derived from their names and addresses. We thank Steffen Kaimer (IAB) for carrying out this procedure for us and providing us with an anonymous file containing an estimated firm ID for every establishment ID and year.

		Poaching sample	Baseline sample
Individual and cell level (apprenticeship completers)			
1a	Apprenticeship duration 700-1,500 days	Yes	Yes
1b	Begin and end dates of apprenticeship in a plausible calendar month (regular apprenticeship year)	Yes	Yes
2	Deletion of wage outliers (less than 50 or more than 200 percent of mean wage in the same training occupation and year)	Yes	Yes
3	All completers must transition into full-time employment	Yes	Yes
4	At least two apprenticeship completers in establishment/occupation/year cell	Yes	No
5a	Deletion of training establishments with zero stayers	Yes	No
5b	Deletion of spurious interfirm mobility (rule out within-firm establishment changes)	Yes	Yes
6a	All completers must transition into full-time employment within 10 days	Yes	(Yes: 30 instead of 10 days)
6b	All completers must transition into full-time employment within the same 2-digit occupation	Yes	Yes
7	Drop if first-job wage < 10€ or > 500€	Yes	Yes
Establishment level (training establishments)			
I	Deletion of outlier establishment observations in terms of apprentice share in total employment, i.e. observations above the 99th percentile	Yes	Yes
II	Deletion of top percentile of establishment observations in terms of employment growth	Yes	Yes
III	Only services and manufacturing	Yes	Yes
Establishment level (hiring establishments)			
I	Deletion of outlier establishment observations in terms of apprentice share in total employment, i.e. observations above the 99th percentile	Yes	Yes
II	Deletion of top percentile of establishment observations in terms of employment growth	Yes	Yes
III	Only services and manufacturing	Yes	Yes

Table B1: Overview of sample construction steps in poaching and baseline sample.

Appendix C

Raiding analysis

To exploit our identification of poaching further, we also consider the effects of regional labor market competition from the perspective of the hiring establishments. The estimation sample now consists of raiders and other hirers, all of which hire at least one external apprenticeship completer (see Figure 2). Inevitably, this reduces the estimation sample size considerably. We can estimate a specification analogous to equation (3) but with the dependent variable being the probability of "raiding" at least one apprenticeship completer from another establishment, and controlling for the number of externally hired apprenticeship completers, rather than the number of own apprentices:

$$\begin{aligned} \mathrm{P}(raider)_{it} = {} & \beta_0 + \beta_1 \ln(ext\_appr\_hires)_{it} + \beta_2 comp_{\mathrm{ort}} + controls + \mu_o \\ & + \delta_j + \vartheta_t + \theta_r \\ & + u_{it}. \end{aligned} \tag{4}$$

Note that there is one important difference to the above estimations, rooted in the change of perspective from training to external hiring establishments. From a training establishments' perspective, all its apprenticeship completers are potential poaching targets (ignoring for the moment the details of our poaching definition). From the perspective of external hirers, all apprenticeship completers within geographical reach (say, within the same labor market region) and in relevant occupations are potential raiding targets. We observe the potential total number of poaching victims only for the training establishments. For the external hirers, we observe only the actually hired external apprenticeship completers.[41] It is plausible to assume that the actually hired apprenticeship completers constitute a positive selection from all those the external establishment could have hired. As a consequence (and confirming this assumption), the share of raidings in all *observed* potential raidings (external apprenticeship completer hires) is relatively high, at 8.4 percent. For comparison, the training establishments' share of poachings in all potential poachings (apprenticeship completers) is only 0.67 percent. Hence, we expect the estimated effect of competition on raiding to be much larger than the effect on being a poaching victim.

This said, estimation results are presented in Table C1. The estimates are indeed much larger than those from the poaching estimation. In absolute values, a one percent increase in competition increases the raiding probability by about 0.1 percentage points, about ten times the estimate of the poaching effect, a factor roughly proportionate to the extent to which the share of raidings in all

[41] Furthermore, we only observe the subset of hires from the observed training establishments (victims and controls). See section 4.2 and Figure 2 in particular.

potential raidings is overstated, as just discussed. Therefore, we find that the effect of regional competition on poaching and raiding (which are, after all, the same thing viewed from different perspectives) is closer to the poaching estimate (plus 0.01 percentage points for a one percent increase in competition).

	(1) Raider	(2) Raider	(3) Raider
log estab. density, region-occupation	.9756*** (6.168)	1.059*** (6.75)	1.135*** (6.675)
log ext. appr. completer hires	.4297*** (4.44)	.489*** (4.892)	.5551*** (5.774)
Log labor (full-time)	.0616* (1.765)	.0207 (.5557)	.0336 (.868)
Share mid-qual. employees	-.0964 (-.5477)	.0616 (.3402)	.0986 (.5009)
Employment growth rate	.0161 (.0699)	.2755 (1.134)	.2573 (1.025)
log median daily wage	.3257** (2.471)	1.081*** (5.732)	1.232*** (5.929)
log employment LM region	.2077** (2.491)	.2262*** (2.624)	.2711 (.0836)
log empl. density LM region	-1.147*** (-6.209)	-1.245*** (-6.592)	-1.334 (-.6038)
Observations	5747	5723	5490
Pseudo R^2	0.097	0.124	0.160
AIC	3614.0	3594.6	3615.8
BIC	3893.6	4200.0	4904.8

Table C1: Impact of regional competition on raiding, external hiring establishments from the poaching sample. *t* statistics in parentheses. Average marginal effects (elasticities) after Probit. All estimations include 2-digit occupation fixed effects. Columns 2-3 includes 2-digit industry and year fixed effects. Column 3 includes labor market region fixed effects. Standard errors clustered at the region-industry level (labor market regions, 2-digit industries). * p<0.10, ** p<0.05, *** p<0.01.