Firm-sponsored Training and Poaching Externalities in Regional Labor Markets*

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Abstract

This paper examines whether firms are less likely to provide apprenticeship training in dense local labor markets, where the probability that workers can be poached by other firms after training is high. Defining regional labor markets based on travel time rather than travel distance or political borders, the results show that firms provide less training in dense labor markets. Applying count data hurdle models to Swiss firm-level data, it can be shown that the effect is strongest at the extensive margin, i.e. to provide any training, but less severe at the intensive margin, which is the number of apprenticeship positions offered once the training decision has been made.

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1 Introduction

Apprenticeship training is of great importance, especially in German speaking countries, but also in other OECD member countries. In Switzerland, about 60% of a cohort enroll in a dual apprenticeship programme after compulsory schooling. Since firms are free to choose whether they want to hire apprentices and train them or simply recruit workers on the external labor market, it is crucial to understand why firms would be willing to train apprentices.
One important determinant of the decision to train are the costs that are associated with it. For Switzerland, training apprentices is profitable on average (for a recent study see Muehlemann et al. 2007). Conversely, an apprenticeship programme is costly from the firm's perspective in Germany (see Beicht et al. 2004). Firms for which training results in net costs during the apprenticeship period must somehow be able to recoup these costs afterwards because otherwise it would not be rational for them to train apprentices. The key determinant to whether such firms will provide training or not is whether they are able to retain a former apprentice after graduation as a skilled worker and pay a wage below worker productivity. In a perfectly competitive labor market, firms and workers have full information about productivity, and the latter are not restrained by mobility costs. Hence, in a competitive setting, firms would not be able to set a wage below productivity without losing the apprentice with a probability equal to one. Since there are about one third of the firms that incur net costs of training in Switzerland, it must be the case that these firms are able to recoup at least part of their investment, otherwise their behavior would not be rational from an economic perspective. While part of the positive net costs could also be explained by firm-specific human capital, it is very unlikely that firm-specific human capital accounts for all of these costs, since the curriculum of vocational training is designed in a way that apprentices learn very general skills with the goal to increase mobility in the labor market.

While labor markets in the real world are not completely competitive, economic theory of industrial organization predicts that competition increases with the number of firms within a market. If training apprentices is indeed mainly general from a human capital point of view, then an apprentice can use these skills for productive activities in any other firm. While workers will not receive a wage equal to their productivity if there are frictions in the labor market (see e.g. Acemoglu and Pischke 1998), the gap between wage and productivity is negatively related to labor market competition. Hence, it should be the case that the training probability is lower if there are many other firms in the same industry that are located closely to the training firm, because increased competition narrows the gap between wage and worker productivity and therefore reduces the probability that a firm can recoup their training investments. Obviously, it should be noted that the threat of poaching is only relevant for firms whose net costs of training are positive.

Studies for the U.K. (Brunello and Gambarotto 2007) and Italy (Brunello and de Paola 2004) have shown that regional effects such as the density of the labor market play an important role in employer-provided training. While Switzerland is a relatively small country with a well developed transportation system, there are still regions where traveling is very time-consuming, especially in mountainous or more rural areas. Since Switzerland is divided in 26 cantons, it would be a natural starting point to define regional labor markets by political borders, especially because Switzerland is very federalistic, i.e. cantons have a high degree of independence with regards to labor market policies and schooling. But while some cantons are too large to be considered a single regional labor market, a number of cantons are very small and economic activities of firms located in such cantons are closely tied with firms located in neighboring cantons. In this paper, regional labor markets are defined by travel time. The relevant regional labor market for a firm is considered to be an area that can be reached by car transportation in less than half an hour.
The effects of labor market competitiveness on the firms demand for apprentices are estimated at the extensive margin, i.e. whether firms provide training or not, and at the intensive margin, which is the number of apprentices hired by training firms. The results show that the a dense labor market reduces the probability of firms to offer training significantly. Furthermore, firms that train apprentices offer slightly less apprenticeship positions if they are located in a region with many other firms close-by that could potentially poach their apprentices.

The paper is organized as follows: Section 2 describes the Swiss apprenticeship system. Section 3 briefly discusses the theory on firm training. Section 4 introduces the data and the sample design. In Section 5 introduces the empirical estimation strategies and presents the results. Section 6 concludes.

2 The Swiss apprenticeship system

Dual apprenticeships are the most important part of the post-compulsory schooling system, with more than 60% of young adults per cohort enrolling in this form of vocational training each year. While an apprenticeship certificate can also be received by graduating from full-time school based forms of education, the dual apprenticeship programmes are the most popular with a share of over 88% of total vocational training.[1]. In total, there are over 200 professions to choose from. Although one of the virtues of the apprenticeship system is its inclusiveness for not so academically prone school leavers (Switzerland has one of the lowest percentages of the over-16 population not having attended any form of non-compulsory schooling in the OECD), apprentices can qualify for further education at the tertiary level. There is a possibility to acquire a professional baccalaureate (either part-time during, or full-time after an apprenticeship programme), which gives access to the universities of applied sciences (Fachhochschule), and - with an extra-curriculum - even to universities. Furthermore, there is an opportunity to enroll in higher vocational education programmes at the tertiary level (ISCED 5B). The proportion of apprentices continuing their education at the tertiary level has steadily risen over the last decade. Hence, from the perspective of an individual, a dual apprenticeship program is in no way a dead end.

The two main types of apprenticeship training programs last either three or four years. During this time, an apprentice spends - depending on the training profession - about 1 to 2 days per week in a public vocational school. During the remainder of the time, the apprentice receives either further on-the-job training by in-house training personnel within the firm or participates in the production process. In the year 2004, Swiss firms invested about 4.7 billion Swiss francs in the training of apprentices (about 1% of GDP), while the value of the apprentices productive work during the training programme amounted to 5.2 billion Swiss francs (Muehlemann

[1]Apprenticeship programs correspond to the OECD classification ISCED 3C

et al., 2007). While apprenticeship training is profitable on average, about one third of all apprenticeship contracts end with positive net costs for the training firm. These figures make it clear that apprentices are, on average, not just cheap substitutes for low-skilled labor. But nevertheless they make a significant contribution to the firms production process. The apprenticeship contract ends automatically at the end of the training program. Hence, if the employer and the apprentice want to continue their employment relationship, they have to negotiate a new labor contract. In Switzerland, mobility of apprentices is relatively high. Only 37% of all apprentices remain in the training firm one year after graduation. This fact is consistent with the costs of apprenticeship training. Because the Swiss labor market is relatively flexible, especially compared to other (European) countries[2], firms are forced to train apprentices in a cost-efficient manner, because the probability that part of the training costs can be recouped later on depends crucially on whether apprentices remain in the training firm or not.

3 Theory

From a theoretical point of view, it is of interest whether the firm or the worker pays for training. If the labor markets are perfectly competitive, firms will not invest in the training of their workers if the acquired human capital is purely general in the spirit of Becker (1964) or transferable in the sense of Stevens (1994), such that the skills can be used productively in other firms. Instead, the workers have to pay for their own training, either directly by paying a tuition fee, or indirectly by accepting a wage below their productivity during the training period.

The recent training literature has tried to explain the frequently observed phenomena that firms are willing to pay for general or transferable training of their workers, which is in contradiction to the traditional human capital theory.[3] There are several theoretical models that can explain such behavior if one considers imperfections in the labor market. For example, Acemoglu and Pischke (1998, 1999) argue that firms will find it optimal to invest in general training if there are frictions in the labor market such as search costs, asymmetric information about worker productivity, firm-specific hu-

[2](see e.g. OECD 1999, p. 57)

[3]For a comprehensive summary of the literature on firm training see Leuven (2005).

man capital, efficiency wages or other wage floors. They show that although firms invest in training, the equilibrium outcome will not be efficient. Instead there will be under-investment in training because not all revenues can be internalized due to the fact that not all apprentices remain in the training firm later on. This behavior is anticipated by a firm ex-ante and results in a deviation from the efficient allocation, which results in sub-optimal investment in training. Hence, if the net costs of training apprentices are positive, as assumed in the model of Acemoglu and Pischke, then training will decrease with the share of the revenues that cannot be internalized. Acemoglu and Pischke (1998) make the assumption that firms are able to counter any wage offers from outside firm that want to poach their apprentices afterwards, which would results in a *winners curse* for these outside firms, because the training firm would bid up to the point where the outside option exceeds productivity. On the other hand, Acemoglu and Pischke (1998) also model that workers might be unhappy in the training firm which gives them a disutility if they remain in the training firm. Thus, if mobility costs are sufficiently high, workers will not change the firm even if they are unhappy. But if there are many potential employers in the same local labor market, mobility costs decrease for obvious reasons, and there will be more apprentices that leave the training firm after graduation. Firms operating in dense labor market will anticipate this behavior, and therefore - if training apprentices is costly - not provide training if the possibility that an apprentice quits after graduation is sufficiently high. As a conclusion, denser labor markets would result in lower firm sponsored training. Stevens (1996) developed a theoretical model where the threat of poaching has an adverse effect on firm-sponsored general training.

But there is also a potential positive effect of dense local labor markets due to knowledge spill-over and diffusion, improved matching due to higher turnover or lower transportation costs in dense areas, which would results in higher productivity (see e.g. Ciccone and Hall 1996; Ciccone 2002). Firms can only achieve higher productivity if they have a skilled workforce that is able to adapt new knowledge and technologies (see e.g. Acemoglu 2002). Brunello and de Paola (2004) highlight an endogeneity problem that might arise because skilled workers potentially move to regions with a high degree of knowledge spill-over, since they will be more productive in such regions due to better technology. However, this endogeneity problem is not likely to play a big role in the case of vocational training, since young adults enter these programs at the age of 16, when they usually still live with their parents and have high mobility barriers. As well, vocational training is a relatively small part of a firms overall strategy, hence it is very unlikely that a firm would relocate for the sole reason of avoiding poaching externalities.

4 Data

4.1 Survey design and data

The data used here are from two representative surveys conducted in Swiss firms in the years 2000 and 2004 by the Centre for Research in Economics of Education at the University of Berne and the Swiss Federal Statistical Office. The survey has been conducted at the establishment-level. All establishments with more than 50 workers have been included in the survey population, whereas firms with less than 50 employees were drawn at random. The Federal Statistical Office has calculated the appropriate weights to account for the survey structure.[4] The data set contains in total 7,593 firms, where 4,312 firms train and 3,281 firms do not train apprentices. A total of 1,265 firms have been excluded because they either operate in the whole country, are part of the federal government or use a centralized training scheme. The reason why these firms have been excluded is that regional labor market characteristics do not influence their training decision. Furthermore, firms that cannot make independent decisions about apprenticeship training because they are part of a larger enterprize have been excluded as well. Detailed data on the number of workers, training profession, number of skilled workers is available at the firm level (see summary statistics in Table 8).

4.2 Regional labor markets

Switzerland is a small country with an area of only 41,000 square kilometers. Despite its small size, Switzerland has a federalistic system with 26 cantons that have their own government and parliament. Cantons have the power to decide on the level of cantonal taxes and to a large extent about the structure of the education system and partly with regards to labor market

[4] All calculations in this paper have been performed using survey weights.

regulations. The lowest level of political decision-making are the communes, which can still make own decisions about communal taxes and to some extent with regards to the education system. Another criteria for a firm to choose its location is the road and railway infrastructure. While transportation is easy and well developed between the major cities in Switzerland, travel time to more remote areas can increase substantially, especially with public transportation.
Hence, the potential employees of a firm are located in a certain perimeter around the firm. Obviously, it is very difficult to define such a perimeter exactly. From a worker's perspective, travel time to work is costly. Thus, for a given wage, a worker will reject a job offer if travel costs are too high, i.e. if the firm is located too far away. While travel distance is costly for a worker due to costs for gasoline or public transportation, these costs are usually small compared to the costs of travel time. From an economic perspective, it is therefore more important to focus on travel time rather than travel distance, especially because travel time is not just a monotone function of travel distance. It is sometimes the case that for, let's say worker A, who is located closer to a firm has to spend more time traveling to work than a worker B who lives further away but has direct access to a highway or fast public transportation.

Summing up, there are several possibilities to define local labor markets:

1. Firstly, political borders such as cantons could be used to define a region of economic activity. But since some cantons are very small and potentially border several other cantons (see Figure 2), it is very likely that the relevant labor market for a firm does not stop at the cantonal border.

2. The second possibility is to define regional labor markets based on travel distance. The advantage of this approach is that it can be implemented rather easily by using a coordinate system. The drawback of this approach is that such regions might not reflect an area of economic activity if there are e.g. mountain ranges or lakes that hinder traveling.

3. Lastly, one could define local labor markets based on travel time. This might be the appropriate choice if time is seen as the driving factor

of transportation costs, which it constitutes most likely for workers. The disadvantage of this approach is that the borders of a region are somewhat ad-hoc, because maximum travel time has to be defined. In addition, the definition of regions is rather complicated because there is no computer-based software that automatically assigns such a region to a firm based on travel time. As well, one has to decide whether travel time of private or public transportation should be used.

Given the federalistic structure of Switzerland with many small cantons and geographic factors such as mountainous areas and lakes that can lengthen travel time considerably even for small distances, a labor market definition based on travel time seems to be the appropriate choice for the potential supply of workers to a firm.

Table 1: Descriptive statistics of regions

Variable	Mean	Median	Min	Max	Obs
Average share of training firms in a region	0.322 (0.100)	0.318	0.129	0.620	67
Average number of local firms in the same industry per hectare	0.023 (0.021)	0.018	0.001	0.093	67

Regions are defined as follows: The 67 largest Swiss cities and towns build the center of a region. From this point, all towns that can be reached by car within 30 minutes constitute a regional labor market.[5]

In densely populated areas, regions can be overlapping, in the sense that a firm located at the intersection between two regions could potentially poach apprentices of firms situated in both regions (see Figure 3). But it should

[5]The maximum travel time of 30 minutes has been chosen somewhat arbitrarily. Of course, it would be possible to allow maximum travel time of up to an hour. Because the research question about the threat of poaching is targeted at very young people between age 17 to 19, a longer travel time than 30 minutes seems rather inadequate, since young people are often more mobility constrained, because e.g. they might not own a car. Furthermore, if the true maximum travel time that individuals are willing to take on would be longer, then the effect of poaching should be smaller. Hence, the estimates presented in the next section should be interpreted as an upper bound. The travel time was measured with the software "Microsoft Autoroute 2005"

be noted that a firm, if it constitutes the dependent variable, always belongs to a single region. If a firm is situated in a town that was not large enough to constitute an own regional center, then it will belong to the center of the region which is closest.[6] The overlapping regions are only relevant for the construction of the independent variable ”local number of firms in the same industry per hectare”. Table 1 shows the descriptive statistics of the average training ratio and the variable of interest, the number of local firms in the same industry per hectare. It can be seen that there is considerable variation of both the training probability of firms and the labor market density across regions.

5 Econometric models and empirical analysis

The empirical estimation strategy will proceed in two steps. In the first subsection, the effect of labor market density on the number of apprenticeship position offered by firms is estimated by local polynomial regression. In the second subsection, the effect of labor market density is estimated by applying multivariate count data models.

5.1 Local polynomial regression

In the following subsection, the functional form of the number of apprentices n_i hired by a firm with respect to regional labor market density is estimated using local polynomial regression. The regression model is of the form

$$n_i = m(d) + \varepsilon_i, \quad i = 1, ..., 7593$$

where d denotes the number local firms in same industry per hectare. We are interested in the functional form $m(d)$, which is linear in the neighborhood of d_0, such that $m(d) = a_0 + b_0(d - d_0)$ in the neighborhood of d_0.[7] The local linear regression estimator minimizes

[6]Obviously, it would be optimal to construct a region including the number of firms in the same industry per hectare for each firm in the sample. But it is doubtful whether the construction of over 7’500 individual regions would have improved the analysis substantially.

[7]see Cameron and Trivedi (2006), p. 320.

$$\sum_{i=1}^{N} K\left(\frac{d_i - d_0}{h}\right)(n_i - a_0 - b_0(d_i - d_0))^2,$$

w.r.t. the parameters a_0 and b_0, where K denotes the Kernel weighting function. As a result, $\hat{m}(d) = \hat{a}_0 + \hat{b}_0(d - d_0)$ in the neighborhood of d_0. There are different estimators that can be applied. An Epanechnikov Kernel with first degree polynomial has been used in the regression displayed in Figure 1.[8]

Obviously, this regression only serves descriptive purposes to illustrate the bivariate relationship between the demand for apprentices and labor market density.

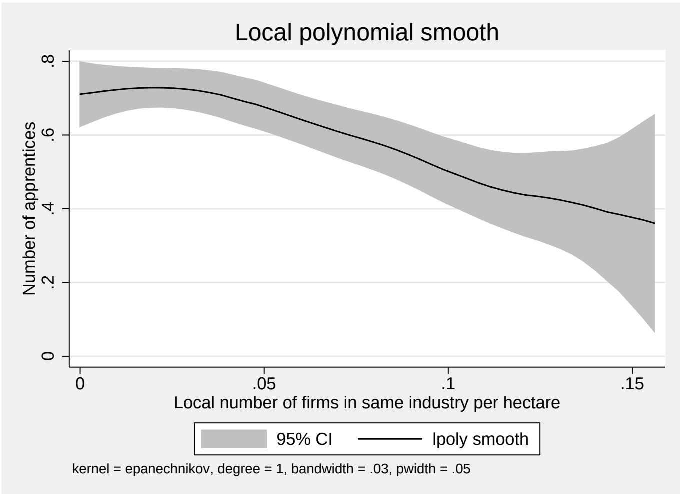

Figure 1: Local polynomial regression

As shown in Figure 1, there is a negative relationship between local labor market density and the number of apprentices a firm hires.

5.2 Count data models

The number of apprentices that a firms chooses to train is a count variable that only takes on nonnegative values. Hence, ordinary least squares regression is not the optimal choice for the analysis. A natural starting point to analyze count data is the Poisson regression model. Let $n_j = 0, 1, 2, \ldots$

[8]The estimations were carried out in Stata using the -lpoly- command.

denote the number of apprentices employed by firm i and d the local labor market density.[9] Then (see e.g. Greene 2003, p.740),

$$\text{Prob}(N_i = n_i|x_i) = \frac{e^{-\lambda_i}\lambda_i^{n_i}}{n_i!}, \quad n_i = 0, 1, 2, ...$$

where $\ln \lambda_i = x_i'\beta$ in the standard loglinear version of the Poisson model; β is the coefficient vector of the explanatory variables x_i. The expected number of apprentices hired by a firm is given by

$$E[n_i|x_i] = \text{Var}[n_i|x_i] = \lambda_i = e^{x_i'\beta}$$

The individual marginal effect of a small change in x_i on $E[n_i|x_i]$ is therefore

$$\frac{\partial E[n_i|x_i]}{\partial x_i} = \lambda_i\beta = E[n_i|x_i]\beta$$

The coefficient vector β can also be interpreted directly as the relative change in $E[n_i|x_i]$ associated with a small change in x_i (see Winkelmann 2003, p.68), since

$$\beta = \frac{\partial E[n_i|x_i]/E[n_i|x_i]}{\partial x_i}$$

The parameter vector β can be estimated with maximum-likelihood techniques and is therefore efficient. The likelihood-function is

$$\ln L = \sum_{i=1}^{k}[-\lambda_i + n_i x_i'\beta - \ln n_i!]$$

The requirement that the mean is equal to the variance is referred to as equidispersion. But this is often not the case. In the data used here, the mean of the number of apprentices [$E(n) = 0.7$] is much smaller than the variance [$\text{Var}(n) = 4.2$]. In the literature, this problem is referred to as overdispersion. While the Poisson regression still yields consistent results even if there is overdispersion, the standard errors will be grossly deflated (see e.g. Cameron and Trivedi 2006, p.670).

[9] To estimate the regression models, the "cluster" command implemented in Stata has been applied, where a regional labor market denotes a cluster. It is assumed that unobserved effects within a cluster uncorrelated with the regressors. Therefore it suffices to adjust the standard errors of the regression coefficients, because the point estimates remain unchanged. For a detailed treatment of data with cluster structure, see e.g. Cameron and Trivedi (2006), pp. 829.

A typical alternative that allows for overdispersion in the data is the negative binomial model. It can be interpreted as a generalization of the Poisson model by introducing unobserved heterogeneity, such that $\ln \mu_i = x_i'\beta + \varepsilon_i$. Hence,

$$E[n_i|x_i, \varepsilon_i] = e^{x_i'\beta+\varepsilon_i} = \mu_i = h_i\lambda_i$$

where $h_i = e^{\varepsilon_i}$ is assumed to have a gamma distribution with mean normalized to 1 and variance $1/\delta$. Thus, $E[n_i|x_i, \varepsilon_i] = \lambda_i$ if $E[h_i] = 1$. Therefore, the interpretation of the parameter vector β remains the same as in the Poisson regression model.[10]

Overall, about 70% of Swiss firms in our sample do not train any apprentices (see Table 2). Neither a Poisson nor a negative binomial model is able

Table 2: Apprentices hired by firms

Apprentices	0	1	2	3	4	5	6	7+
Frequency	70.05	13.25	9.08	3.61	1.82	0.78	0.43	0.98
Cumulative freq.	70.05	83.3	92.38	96	97.82	98.6	99.02	100

to predict such an "excess of zeros". To overcome this problem, so-called hurdle models can be applied that relax the assumption that zeros and positive outcomes are the results of the same data generating process. A count data hurdle model combines a binary model for the training decision with a truncated-at-zero count data model for the number of apprentices employed by training firms (for a detailed exposition see e.g. Winkelmann 2003). From an economic perspective, these models can be interpreted as a two-stage decision process.

In this paper, firms are assumed to first make a decision whether apprenticeship training is desirable in their firm or not. Many small and specialized firms are not be able to engage in apprenticeship training because they do not have the necessary infrastructure or training personnel. For some firms, the relevant profession in which they have a need for skilled workers might not even exist in the form of an apprenticeship programme, hence they are forced to recruit workers on the external labor market. Once the basic decision has been made as to whether apprentices should be trained or not,

[10]Different distributions could be chosen for the error term ε_i, such as the normal distribution, which leads to a Poisson-log-normal model. For a detailed treatment see e.g. Winkelmann (2003). See Appendix A for a detailed derivation of the negative binomial model as a poisson-gamma-mixture.

a firm will choose the optimal number of apprentices it wants to hire. A hurdle model allows to test whether the effects of the variables of interest are the same at the hurdle and for positive outcomes of the count variable.

The zero outcomes are determined by a density $f_1(\cdot)$, such that $f(n = 0) = f_1(0)$. Positive outcomes are determined by a truncated density $f_2(\cdot)$ such that $f(n = k) = \frac{1-f_1(0)}{1-f_2(0)} f_2(k), k = 1, 2, 3, ...$ Hence, the probability distribution of a hurdle-at-zero model is given by

$$g(n) = \begin{cases} f_1(0) & \text{if} \quad n = 0 \\ \frac{1-f_1(0)}{1-f_2(0)} f_2(n) & \text{if} \quad n \geq 1 \end{cases}$$

A standard model is the Poisson hurdle model proposed by Mullahy (1986) with f_1 and f_2 being two Poisson distributions, where $\lambda_{1i} = e^{x_i'\beta_1}$ and $\lambda_{2i} = e^{x_i'\beta_2}$. The advantage of this model is that it nests the simple Poisson model. Hence, the parametric restriction $H_0 : \beta_1 = \beta_2$ can be tested using a Wald test. If H_0 cannot be rejected, the Poisson hurdle model reduces to the standard model since $f_1 = f_2$. The likelihood function of the Poisson hurdle model (see e.g. Winkelmann 2003) is given by

$$\begin{aligned} L &= \prod_{i=1}^{k} \exp(-\exp(x_i'\beta_1))^{d_i} [1 - \exp(-\exp(x_i'\beta_1))]^{1-d_i} \\ &\times \left[\frac{\exp(-\exp(x_i'\beta_2)) \exp(n_i x_i'\beta_2)}{n_i! \exp(-\exp(x_i'\beta_2))} \right]^{1-d_i} \end{aligned}$$

where $d_i = 1 - \min\{n_i, 1\}$

Besides the Poisson hurdle model, there are other possible specifications, such as the logit-negative binomial hurdle model, which combines a logit model for the hurdle and a truncated-at-zero negative binomial model for positive outcomes. The results of this model will be presented in the next section.[11]

The main interest of this paper are the elasticity of the firm's demand for apprentices n with respect to the local labor market density d at the extensive

[11] Many other specifications are possible, such as the Probit-Poisson-log-normal model, with a probit model at the hurdle and a truncated-at-zero Poisson-log-normal distribution for positive outcomes (see e.g. Winkelmann 2003 for a detailed treatment, or Muehlemann et al. 2007 for a recent empirical application to vocational training). This model will not be applied in this paper because it has not yet been implemented for the use of survey weights and the calculation of cluster-robust standard errors.

margin, which is given by

$$\eta_1 = \frac{\partial P(n>0)}{\partial d}\frac{d}{P(n>0)}$$

and the elasticity at the intensive margin, given by

$$\eta_2 = \frac{\partial E(n|n>0)}{\partial d}\frac{d}{E(n|n>0)}$$

The overall elasticity equals $\eta_1 + \eta_2$ since $E(n) = P(n > 0)E(n|n > 0)$.

The advantage of hurdle models is that they allow for different effects of the independent variables in different parts of the distribution. For example, the effect of labor market density could have a negative impact at the hurdle, i.e. on the training decision, but no impact on the demand for apprentices one a firm has decided to train. The simple Poisson model does not allow for this because both η_1 and η_2 are functions of a single index and the same parameter β.
The estimation strategy is as follows: First, simple Poisson and negative binomial regression models are estimated and then compared to hurdle models. It will then be tested whether hurdle models are the appropriate statistical tools to model the firm's demand for apprentices.

5.3 Results

The results of the simple Poisson regression (Table 4) show that the local number of firms per hectare have a negative and highly significant effect on the number of apprentices hired by firms. This results does not change much if a negative binomial model is applied. While the null hypothesis of no overdispersion can be rejected by a likelihood ratio test of the dispersion parameter ($H_0 : \alpha = 0$), the coefficient on local labor market density does not change by much and remains negative and significant (Table 5).
The Poisson hurdle model gives additional insights with regards to the effect of local labor market density (Table 6). While the coefficient if interest is negative and highly significant at the hurdle, it is still negative but small and not significant for positive outcomes. To test the hurdle model against the simple Poisson model, a Wald test can be performed. The null hypothesis $H_0 : \beta_1 = \beta_2$ that the coefficients are the same at the hurdle and in the positive part is clearly rejected, since the Wald statistic of 959.19 is a realization

of a $\chi^2(31)$ distribution with a critical value of 44.99.[12] The logit-negative binomial hurdle model is superior to the Poisson hurdle model based e.g. on the Akaike Information Criterion. The coefficient on local labor market density is somewhat larger both at the hurdle and in the positive part (Table 7). Compared to the Poisson hurdle model, the coefficient on local labor market density is now significant at the 10%-level in the positive part, but still fairly small.

To compare the effects of local labor market density across models and to give it an economic interpretation, the elasticity of demand for apprentices with respect to the local number of firms in the same industry per hectare has been calculated for the models mentioned above (Table 3). Furthermore, a number of robustness checks are presented as well.
In the Poisson model, the elasticity is -0.227 if industry and job variables are included. To account for possible regional fixed effects, further model specifications have been estimated. Due to the federalistic system in Switzerland, it could be suspected that the results are driven by canton-specific effect. Hence, a dummy variable has been included for each canton to control for such fixed effects. Some of these canton dummy variables were indeed significant; the elasticity of demand with respect to local labor market density decreases to -0.175, but the effect is still significant at the 1%-level. To account for the possibility that there are regional labor market effects as well, a model with a dummy variable for each of the 67 regions has been estimated as well. The elasticity is very similar compared to the model with canton fixed effects.
The results of the negative binomial model are similar to the Poisson regression model, although the elasticities are somewhat higher, especially in the models with canton and region fixed effects.

Hurdle models give additional insights about the effect of local labor market density on the demand for apprentices. The elasticity at the extensive margin is equal to -0.267 in the Poisson hurdle model. If canton and region dummy variables are included, the elasticity decreases somewhat, but remains negative and significant, amounting to -0.203 and -0.213 respectively.

[12] The coefficients have been estimated with Quasi-Maximum-Likelihood techniques. While the likelihood-ratio test is not valid anymore because it is based directly on the value of the log-likelihood, Wald test statistics are still valid.

Table 3: Elasticity of demand w.r.t. labor market density

Model	Elasticity	Controls			
		Industry	Job	Canton	Region
Poisson	-0.227	Yes	Yes	No	No
	-0.175	Yes	Yes	Yes	No
	-0.175	Yes	Yes	No	Yes
Negative binomial	-0.248	Yes	Yes	No	No
	-0.212	Yes	Yes	Yes	No
	-0.225	Yes	Yes	No	Yes
Poisson Hurdle					
-Training yes/no	-0.267	Yes	Yes	No	No
	-0.203	Yes	Yes	Yes	No
	-0.213	Yes	Yes	No	Yes
-No. of apprentices 1+	-0.037	Yes	Yes	No	No
	-0.047	Yes	Yes	Yes	No
	-0.057	Yes	Yes	No	Yes
Logit-negative binomial					
-Training yes/no	-0.293	Yes	Yes	No	No
	-0.228	Yes	Yes	Yes	No
	-0.246	Yes	Yes	Yes	Yes
-No. of apprentices 1+	-0.050	Yes	Yes	No	No
	-0.065	Yes	Yes	Yes	No
	-0.081	Yes	Yes	No	Yes

The elasticity at the intensive margin is only -0.05. This illustrates that labor market density has very different effects at different points of the distribution. The results support the hypothesis that the threat of poaching has a much stronger effect on the decision to train apprentices than on the number of apprentices hired, on the training decision has been made. This result is intuitive, since rational firms should expect potential poaching of neighboring firms and decide not to train if training itself is costly, and the probability to recoup part of the investment after the training period is low. But once a firm decides to train, the threat of poaching does not induce firms to reduce the number of apprentices they hire very much. While the elasticity in the positive part is not significant in the Poisson hurdle model, it is marginally significant in the logit-negative binomial model, but the economic effect remains relatively small with an elasticity between -0.05

and -0.08.[13]

The results that the effect of local labor market density is negative and significant at the extensive margin are in line with the findings of Harhoff and Kane (1997) for apprenticeship training in Germany, and Brunello and de Paola (2004); Brunello and Gambarotto (2007) using data on training participation for Italy and the UK. Harhoff and Kane (1997) found a marginally significant effect of the number of firms in the same industry per county on the intensity of apprenticeship training, i.e. the ratio of apprentices and workers. So far, there is no study known to the author that estimated the effect of local labor market density at the intensive margin on the demand of apprentices.

The effects of other explanatory variables on the demand for apprentices are similar to previous studies, see e.g. Muehlemann et al. (2007); Wolter et al. (2006); Muehlemann and Wolter (2007). The number of skilled workers in the training profession has a strong effect both at the extensive and intensive margin with an elasticity of 0.72 and 0.6 respectively in the logit-negative binomial model (Table 7). The number of other workers in a firm also has a significant and positive effect, but its economic impact is relatively small with an elasticity of 0.05 both at the hurdle and in the positive part. Furthermore, foreign-owned firms and firms in the French and Italian part of Switzerland train significantly less apprentices, which again confirms the results from previous studies.

6 Conclusions

Using a new approach to model regional labor markets based on travel time, this paper analyzes the effects of local labor market density on the firms' demand for apprentices. The results show that firms have a higher demand for apprentices in more isolated labor market where fewer firms are around to

[13]The observed net costs of apprenticeship training have also been included in the positive part of the hurdle model. While the effect of the net costs was small with a cost elasticity equal to -0.023, the coefficient of local labor market density did not change due to the inclusion of the net cost variable. Therefore, the costs and benefits of apprenticeship training have not been included since it does not affect the variable of interest in this paper. See Muehlemann et al. (2007); Wolter et al. (2006) for the effects of net costs of apprenticeship training based on the survey-data of the year 2000 only.

poach their apprentices after training. Applying count data hurdle models, it can be shown that the demand elasticity with respect to labor market density is -0.25 at the extensive margin, i.e. whether firms provide training or not, but only -0.08 at the intensive margin. Hence, the threat that local firms might poach apprentices after training seems to be real and reduces the probability of firms to train apprentices.

This result has an important implication for policy purposes. For a firm, the threat of poaching is only relevant if the expected net costs of training are positive. Hence, it is important that training regulations allow firms to train apprentices without having to bear net costs of training - as it is the case for about two thirds of the training programmes in Switzerland - since it will not matter for the firm if the apprentice leaves after the training period, as long as training itself does not result in net costs from the firm's perspective.

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Appendix

A Negative binomial model

The distribution of n_i conditional on x_i and $h_i(\varepsilon_i)$ is Poisson with mean and variance μ_i:

$$f(n_i|x_i, h_i(\varepsilon_i)) = \frac{e^{-\mu_i}\mu_i^{n_i}}{n_i!}$$

The distribution of n_i conditional on x_i but unconditional on $h_i(\varepsilon_i)$ is obtained by integrating out $h_i(\varepsilon_i)$:

$$f(n_i|x_i) = \int_0^\infty \frac{e^{-\mu_i}\mu_i^{n_i}}{n_i!} g(h_i) dh_i$$

Since $h_i(\varepsilon_i)$ is gamma distributed and the mean normalized to 1, we get the negative binomial as a mixture density:

$$\begin{aligned}
f(n_i|x_i) &= \int_0^\infty \frac{e^{-\mu_i}\mu_i^{n_i}}{n_i!} \frac{h_i^{\delta-1}e^{-h_i\delta}\delta^\delta}{\Gamma(\delta)} dh_i \\
&= \int_0^\infty \frac{e^{-\lambda_i h_i}\lambda_i h_i^{n_i}}{n_i!} \frac{h_i^{\delta-1}e^{-h_i\delta}\delta^\delta}{\Gamma(\delta)} dh_i \\
&= \int_0^\infty \frac{e^{(-\lambda_i+\delta_i)h_i}\lambda_i^{n_i}}{n_i!} \frac{h_i^{n_i+\delta-1}\delta^\delta}{\Gamma(\delta)} dh_i \\
&= \frac{\lambda^n\delta^\delta}{\Gamma(\delta)n!} \int_0^\infty e^{-(\lambda_i+\delta_i)h_i}\lambda_i^{n_i+\delta-1} dh_i \\
&= \frac{\lambda^n\delta^\delta\Gamma(n_i+\delta)}{\Gamma(\delta)n!(\lambda_i+\delta)^{n_i+\delta}} \\
&= \frac{\Gamma(\alpha^{-1}+n_i)}{\Gamma(\alpha^{-1})\Gamma(n_i+1)} \left(\frac{\alpha^{-1}}{\alpha^{-1}+\lambda_i}\right)^{\alpha^{-1}} \left(\frac{\lambda_i}{\lambda_i+\alpha^{-1}}\right)^{n_i}
\end{aligned}$$

where $\alpha = 1/\delta$, $\delta > 0$ and $\Gamma(\cdot)$ denotes the gamma integral.

B Figures

Figure 2: *Cantons of Switzerland* (Source: Swisstopo)

Figure 3: *Regions including several cantons* (Source: Swisstopo)

C Tables

Table 4: Poisson regression

Dependent variable:	Number of apprentices	
	Coeff.	Std.err.
Local number of firms in industry per hectare	-6.3872	(1.1323)
Ln(Number of skilled workers in training profession)	0.7761	(0.0295)
Ln(Number of other employees in firm)	0.0431	(0.0047)
Foreign firm-ownership	-0.5782	(0.0995)
French part of Switzerland	-0.5550	(0.0957)
Italian part of Switzerland	-0.5293	(0.1059)
Construction	-0.2902	(0.0918)
Food,beverages, tobacco	-0.8270	(0.1720)
Textiles, leather, shoes	-0.5651	(0.2117)
Crafts (Wood)	-0.1524	(0.1323)
Paper, print, media	-0.4161	(0.1164)
Chemical, oil	-0.4681	(0.1464)
Metal manufacturing	-0.3798	(0.1429)
Machine, automotive manufacturing	-0.3663	(0.1503)
Manufacturing office equipment, medical, watches	-0.5659	(0.1288)
Furniture, jewelry, toys, recycling	-0.6029	(0.1962)
Hotel, restaurant	-1.2981	(0.1561)
Transport, communication	-0.9450	(0.1575)
Banking, insurance	-0.3986	(0.2254)
Real estate, IT, research	-0.4081	(0.0806)
Education	-1.0194	(0.2326)
Health, social institutions	-0.5179	(0.1453)
other services, culture, sport, entertainment	-0.4854	(0.1213)
Administrative assistant	-0.6502	(0.1031)
Polymechanics technician	0.0227	(0.1252)
IT specialist	-0.5138	(0.1721)
Cook	0.6983	(0.1188)
Electrician	0.4482	(0.1134)
Bricklayer	-0.8173	(0.1668)
Sales clerk	-0.2111	(0.1144)
Survey in year 2000 (1=yes/0=no)	-0.0747	(0.0491)
Constant	-0.5357	(0.0967)
Log pseudolikelihood	-435,083.6	
Observations	7593	

Standard errors in parentheses are adjusted for clustering. Number of clusters: 67. The reference category is a firm in the German part of Switzerland in the trade, retail and whole sale industry surveyed in the year 2004.

Table 5: Negative binomial regression

Dependent variable:	Number of apprentices	
	Coeff.	Std.err.
Local number of firms in industry per hectare	-6.9823	(1.2174)
Ln(Number of skilled workers in training profession)	0.7284	(0.0465)
Ln(Number of other employees in firm)	0.0497	(0.0053)
Foreign firm-ownership	-0.7415	(0.0894)
French part of Switzerland	-0.5587	(0.0838)
Italian part of Switzerland	-0.3962	(0.0991)
Construction	-0.3777	(0.0895)
Food,beverages, tobacco	-0.8233	(0.1847)
Textiles, leather, shoes	-0.6797	(0.2182)
Crafts (Wood)	-0.2168	(0.1399)
Paper, print, media	-0.5323	(0.1406)
Chemical, oil	-0.6163	(0.1374)
Metal manufacturing	-0.4518	(0.1438)
Machine, automotive manufacturing	-0.3361	(0.1106)
Manufacturing office equipment, medical, watches	-0.5994	(0.1600)
Furniture, jewelry, toys, recycling	-0.6549	(0.2331)
Hotel, restaurant	-1.4410	(0.1844)
Transport, communication	-0.9261	(0.1863)
Banking, insurance	-0.3649	(0.2422)
Real estate, IT, research	-0.4140	(0.0709)
Education	-1.0067	(0.2459)
Health, social institutions	-0.6765	(0.0956)
other services, culture, sport, entertainment	-0.4590	(0.1179)
Administrative assistant	-0.6778	(0.1288)
Polymechanics technician	-0.1170	(0.1216)
IT specialist	-0.5720	(0.2003)
Cook	0.7105	(0.1438)
Electrician	0.3910	(0.1228)
Bricklayer	-0.8357	(0.1709)
Sales clerk	-0.3369	(0.1237)
Survey in year 2000 (1=yes/0=no)	-0.0716	(0.0453)
Constant	-0.4001	(0.1042)
Log pseudolikelihood	-403,045.9	
Observations	7503	

Standard errors in parentheses are adjusted for clustering. Number of clusters: 67. The reference category is a firm in the German part of Switzerland in the trade, retail and whole sale industry surveyed in the year 2004.

Table 6: Poisson Hurdle Model

Dependent variable:	Training yes/no		No. of app. 1+	
	Coeff.	Std.err.	Coeff.	Std.err.
Local number of firms in industry per hectare	-8.3443	(1.2824)	-1.1474	(0.7552)
Ln(Number of skilled workers in training prof.)	0.5896	(0.0369)	0.5982	(0.0339)
Ln(Number of other employees in firm)	0.0338	(0.0057)	0.0422	(0.0051)
Foreign firm-ownership	-0.9205	(0.1110)	-0.0315	(0.0709)
French part of Switzerland	-0.5370	(0.0801)	-0.2851	(0.1161)
Italian part of Switzerland	-0.2575	(0.1231)	-0.4810	(0.0987)
Construction	-0.2702	(0.0977)	-0.2688	(0.1039)
Food,beverages, tobacco	-0.8882	(0.2177)	-0.4272	(0.1338)
Textiles, leather, shoes	-0.8689	(0.3057)	-0.0578	(0.1880)
Crafts (Wood)	-0.1202	(0.1667)	-0.0706	(0.1378)
Paper, print, media	-0.4281	(0.1782)	-0.2339	(0.0815)
Chemical, oil	-0.7335	(0.1601)	-0.1488	(0.1012)
Metal manufacturing	-0.4864	(0.1690)	-0.0943	(0.1249)
Machine, automotive manufacturing	-0.4601	(0.1501)	-0.0176	(0.1424)
Manufacturing office equipment, medical	-0.7842	(0.1967)	-0.0924	(0.1003)
Furniture, jewelry, toys, recycling	-0.6930	(0.2676)	-0.2997	(0.1460)
Hotel, restaurant	-1.6166	(0.1928)	-0.0969	(0.1469)
Transport, communication	-1.1782	(0.2082)	-0.1201	(0.1576)
Banking, insurance	-0.7865	(0.2908)	0.2272	(0.0977)
Real estate, IT, research	-0.3839	(0.0815)	-0.2552	(0.0792)
Education	-1.3263	(0.2346)	-0.0259	(0.1871)
Health, social institutions	-0.6018	(0.1127)	-0.0923	(0.2209)
other services, culture, sport, entertainment	-0.8128	(0.1166)	0.1757	(0.0969)
Administrative assistant	-0.6329	(0.1223)	-0.5079	(0.0623)
Polymechanics technician	-0.4303	(0.1494)	0.1543	(0.1218)
IT specialist	-0.7734	(0.1766)	-0.2735	(0.1277)
Cook	0.7958	(0.1734)	-0.0229	(0.1620)
Electrician	0.0203	(0.1450)	0.7601	(0.1110)
Bricklayer	-0.9251	(0.2044)	-0.3313	(0.1384)
Sales clerk	-0.5803	(0.1745)	0.1863	(0.1253)
Survey in year 2000 (1=yes/0=no)	-0.1407	(0.0697)	0.0309	(0.0449)
Constant	-0.4437	(0.1038)	-0.2773	(0.0924)
Log pseudolikelihood	-400,328.0			
Observations	3281		4312	

Standard errors in parentheses are adjusted for clustering. Number of clusters: 67. The reference category is a firm in the German part of Switzerland in the trade, retail and whole sale industry surveyed in the year 2004.

Table 7: Logit-negative binomial hurdle model

Dependent variable:	Training yes/no		No. of app. 1+	
	Coeff.	Std.err.	Coeff.	Std.err.
Local number of firms in industry per hectare	-10.1379	(1.5411)	-1.5669	(0.8362)
Ln(Number of skilled workers in training prof.)	0.7246	(0.0679)	0.6052	(0.0341)
Ln(Number of other employees in firm)	0.0492	(0.0069)	0.0453	(0.0053)
Foreign firm-ownership	-1.1021	(0.1365)	-0.0991	(0.0721)
French part of Switzerland	-0.6538	(0.0971)	-0.2845	(0.1165)
Italian part of Switzerland	-0.2420	(0.1521)	-0.4693	(0.0988)
Construction	-0.3221	(0.1336)	-0.3418	(0.1076)
Food,beverages, tobacco	-1.0897	(0.2700)	-0.4357	(0.1479)
Textiles, leather, shoes	-1.0914	(0.3722)	-0.1011	(0.1865)
Crafts (Wood)	-0.1469	(0.2312)	-0.1088	(0.1457)
Paper, print, media	-0.5721	(0.2333)	-0.3168	(0.0965)
Chemical, oil	-0.9269	(0.1959)	-0.2358	(0.1078)
Metal manufacturing	-0.6010	(0.2276)	-0.0867	(0.1206)
Machine, automotive manufacturing	-0.5192	(0.2005)	-0.0382	(0.1244)
Manufacturing office equipment, medical appl.	-0.9641	(0.2546)	-0.1196	(0.1256)
Furniture, jewelry, toys, recycling	-0.8559	(0.3512)	-0.3084	(0.1644)
Hotel, restaurant	-1.9842	(0.2266)	-0.1456	(0.1500)
Transport, communication	-1.3693	(0.2561)	-0.1670	(0.1622)
Banking, insurance	-0.8815	(0.3698)	0.2681	(0.1196)
Real estate, IT, research	-0.4761	(0.0999)	-0.2688	(0.0797)
Education	-1.5788	(0.2829)	-0.0360	(0.2153)
Health, social institutions	-0.7441	(0.1414)	-0.3341	(0.1429)
other services, culture, sport, entertainment	-0.9757	(0.1425)	0.2427	(0.0968)
Administrative assistant	-0.7754	(0.1638)	-0.4938	(0.0641)
Polymechanics technician	-0.6472	(0.1906)	0.1480	(0.1146)
IT specialist	-0.9610	(0.2146)	-0.1948	(0.1411)
Cook	0.8917	(0.2159)	0.0366	(0.1596)
Electrician	0.0046	(0.2051)	0.7873	(0.1176)
Bricklayer	-1.2452	(0.2595)	-0.2566	(0.1393)
Sales clerk	-0.7565	(0.2141)	0.1931	(0.1290)
Survey in year 2000 (1=yes/0=no)	-0.1432	(0.0824)	0.0119	(0.0470)
Constant	-0.0925	(0.1324)	-0.3440	(0.0935)
Log pseudolikelihood	-393,715.7			
ln *alpha*			-1.4726	(0.1663)
Observations	3281		4312	

Standard errors in parentheses are adjusted for clustering. Number of clusters: 67. The reference category is a firm in the German part of Switzerland in the trade, retail and whole sale industry surveyed in the year 2004.

Table 8: Summary statistics

Variable	Mean	Std. Dev.	Min	Max	Obs
Training firm	0.294	0.455	0	1	7593
Local number of firms in industry per hectare	0.036	0.038	0	0.156	7593
Number of skilled workers in training profession	4.823	18.440	0	2400	7593
Number of other workers in firm	11.002	60.755	0	4610	7593
Foreign firm-ownership	0.108	0.310	0	1	7593
French part of Switzerland	0.236	0.424	0	1	7593
Italian part of Switzerland	0.029	0.167	0	1	7593
Industry dummies					
Construction	0.112	0.316	0	1	7593
Food,beverages, tobacco	0.012	0.109	0	1	7593
Textiles, leather, shoes	0.004	0.066	0	1	7593
Crafts (Wood)	0.020	0.140	0	1	7593
Paper, print, media	0.015	0.121	0	1	7593
Chemical, oil	0.010	0.100	0	1	7593
Metal manufacturing	0.025	0.157	0	1	7593
Machine, automotive manufacturing	0.014	0.117	0	1	7593
Manufacturing office equipment, medical, watches	0.017	0.127	0	1	7593
Trade, retail, wholesale	0.262	0.440	0	1	7593
Furniture, jewelry, toys, other equipment	0.011	0.105	0	1	7593
Hotel, restaurant	0.110	0.313	0	1	7593
Transport, communication	0.033	0.179	0	1	7593
Banking, insurance	0.027	0.161	0	1	7593
Real estate, IT, research	0.169	0.375	0	1	7593
Public administration, national security	0.032	0.175	0	1	7593
Education	0.070	0.255	0	1	7593
Health, social institutions	0.057	0.233	0	1	7593
Training professions					
Administrative assistant	0.222	0.416	0	1	7593
Polymechanics technician	0.018	0.134	0	1	7593
IT specialist	0.030	0.171	0	1	7593
Cook	0.068	0.252	0	1	7593
Electrician	0.021	0.142	0	1	7593
Bricklayer	0.020	0.142	0	1	7593
Sales clerk	0.045	0.206	0	1	7593
Year of survey=2000	0.511	0.500	0	1	7593