Graduate migration in Germany – new evidence from an event history analysis

Christian Teichert[(a)], Annekatrin Niebuhr[(b)], Anne Otto[(c)], Anja Rossen[(d)]

Abstract

We apply event history methods to investigate graduate migration in Germany focusing on moves that are linked to labour market entry of the young workers. We observe significant changes in the share of stayers up to seven years after graduation. Individual characteristics, study-related factors and regional characteristics impact on the location of labour market entry and changes of the residence. Moreover, the employment biography influences the decision to leave the region of study. In particular, work experience gathered in- or outside the university regions matters, pointing to the importance of labour market contacts and social networks. Finally, the results suggest that there is no genuine negative duration dependence when the graduate migration is concerned. It seems that the negative relationship between the probability of leaving the region of study and the length of a residence spell is entirely driven by observed and unobserved graduate characteristics. In contrast, there is some indication for cumulative stress when labour market entry outside the university region is considered.

Keywords: migration, graduates, labour market entry, duration analysis

JEL: C41, J61, R23

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(a) Institute of Economic and Cultural Geography, Department of Geography, Leibniz-Universität Hannover, Schneiderberg 50, D-30167 Hannover, Germany, Email: teichert@wigeo.uni-hannover.de

(b) Institute for Employment Research, IAB Nord, Projensdorfer Str. 82, D-24106 Kiel, Germany, Email: Annekatrin.Niebuhr@iab.de
Empirical Labour Economics and Spatial Econometrics, Department of Economics, Christian-Albrechts-Universität zu Kiel, Olshausenstr. 40, D-24098 Kiel, Germany, Email: niebuhr@economics.uni-kiel.de

(c) Institute for Employment Research, IAB Rhineland-Palatinate-Saarland, Eschberger Weg 68, D-66121 Saarbrücken, Germany, Email: Anne.Otto@iab.de

(d) Institute for Employment Research, IAB Bavaria, Thomas-Mann-Str. 50, D-90478 Nuremberg, Germany, Email: Anja.Rossen4@iab.de

1. Introduction

Human capital is a key determinant of regional development and universities are supposed to play a crucial role for human capital accumulation in regions (Gennaioli et al. 2013, Haapanen & Tervo 2012). However, graduates of local universities will only increase the human capital endowment if they stay in the university region and especially for smaller regions out-migration of graduates might be an issue because these areas likely face problems attracting young high-skilled workers. Instead the young highly educated tend to move to large urban agglomeration (Krabel &Flöther 2014, Venhorst 2013). Therefore, understanding the migration decision of graduates is of particular importance for less developed regions with institutions of higher education (Haapanen & Tervo 2012).

By now there is a voluminous literature on student and graduate migration. Most studies investigate the factors that impact on migration decision making. One group of analyses uses information on the aggregate level and aims at explaining interregional migration flows. For example, Faggian and McCann (2008) investigate the interdependence between graduate migration and the innovation performance of regions using a simultaneous equation model. Some studies apply gravity models to investigate the determinants of migration flows of students and graduates (e.g. Delisle & Sheamur 2010, Dotti et al. 2013, Faggian & Franklin 2014).

Another group of studies makes use of individual level information. Often the focus of these papers is on the probability of graduates to migrate after finishing their studies. Probit and logit models are estimated to identify individual characteristics and regional factors that influence the decision to leave the university region and to belong to different migration types (e.g. Faggian et al. 2006, Faggian et al. 2007, Krabel & Flöther 2014). Other studies investigate the destination choice of graduates based on multinomial logit models (e.g. Gottlieb & Joseph 2006, Haussen & Uebelmesser 2015).

The time dimension does not really matter in most of these analyses. Usually a move is identified by comparing the region of residence for two dates, frequently on an annual basis. Survey data often provides information on the residence of graduates one or five years after completing the degree. Neither aggregate level analyses nor micro-econometric models that focus on the probability of a move or the destination choice provide information on whether most graduates immediately leave the region of study after graduation or maybe two or five years later after first entering the labour market in the region of study.

We apply event history methods to provide new evidence on graduate migration in Germany. The focus is on moves that are linked to labour market entry of the graduates. By applying event history methods we are able to investigate the sequence of the migration process in more detail. Only a few studies that investigate the mobility of young high-skilled workers use this approach up to now. Busch & Weigert (2010) apply duration analysis to investigate graduate migration in Germany. They use information on German graduates for the period between 1984 and 2004 from an annual household survey. A drawback of their analysis is the rather small sample size (around 900 persons). Moreover, information on the region of residence is only available on the level of federal states and on an annual basis. The latter also applies to a study Haapanen & Tervo (2012) who provide evidence on graduate migration in Finland. Using census data on Finnish university graduates from 1991 to 2003 they analyse

out-migration from the university region over a period of 13 years after graduation. The results indicate that the time dimension indeed matters. The probability of migration in the subsequent year increases two years before the students finish their studies and starts to decline one year after graduation. Both studies point to a significant negative duration dependence, i.e. the propensity to leave the region of studies declines as the length of the residence spell increases.

Our analyses provides new evidence on the timing of migration and the significance of duration dependence. Moreover, information on both the residence and the place of work allows us to consider different definitions of a move. And finally, we consider the impact of the employment biography of the graduates on the decision to leave the region of studies. In particular, we investigate whether work experience before and during the studies influences the migration behaviour. The literature on graduate migration has largely neglected these factors so far. Findings by Krabel & Flöther (2014) indicate that graduates' contacts with local employers affect their migration behaviour. Previous work experience likely reflects the establishment of job-search networks as emphasized by Granovetter (1973). Kramarz & Nordström Skans (2014) point out the significance of networks for labour market entry of young graduates. Thus, depending on where the work experience has been gathered, work experience might increase or reduce the probability of out-migration after graduation.

The rest of the paper is organized as follows. The next section reviews the literature on graduate migration and briefly discusses the theoretical framework. In the sections 3 and 4, we describe the duration models which we apply in order to investigate graduate migration in Germany and the data set. The results of the duration analysis are discussed in Section 5. Section 6 concludes.

2. Literature and theoretical framework

The literature on graduate migration has largely disregarded the time dimension of regional mobility. The majority of studies resort to regional human capital models (e.g., Sjaastad 1962) that consider the individual migration decision as a utility-maximizing location choice between destinations that is influenced by individual factors such as age and gender and contextual factors such as regional labour market conditions and amenities. The location decision of graduates is investigated at specific points in time, mostly one to three years after graduation. But this leaves unresolved the issue of how the migration behaviour develops over time (Haapanen & Tervo 2012).

Instead, the behavioural model of cumulative stress and inertia (Huff & Clark 1978) views the migration decision as a dynamic process. Two conflicting forces determine the likelihood of moving: There is a certain resistance to moving *(cumulative inertia)* on the one side and circumstances which accelerate a migration process *(residential stress)* on the other. The longer a person lives in a region the stronger becomes the personal attachment to that area, due to 'location-specific knowledge' (DaVanzo 1983) through previous experiences leading to knowledge of local circumstances or through social networks. On the other hand, out-migration can be triggered by residential stress factors such as a lack of inadequate jobs and residential opportunities in the region. An individual's probability to move – as result of these

interacting forces – can thus change over time. Hence, the duration of a spell in a particular region may impose a distinct causal effect on the migration decision (Andrews et al. 2011). In this setting, the migration decision corresponds to the termination of a continuous spell of residence, and the length of these spells varies across individuals (Haapanen & Tervo 2012).

A small set of migration studies dealing with internal mobility of individuals applies the model of cumulative stress and inertia and provides evidence for a negative duration dependence in different countries. For the UK, Andrews et al. (2011) show that the probability of outmigration declines as the length of a residence spell increases. Negative duration dependence pointing to dominating cumulative inertia are found by Gerber (2005) for spatial mobility in Russia and by Detang-Dessendre & Molho (1999, 2000) for long-distance moves of young school leavers in France. In addition, studies on international migration indicate that the probability of return migration decreases the longer the migrants reside in the host country (e.g., Van den Berg & Weynandt 2013).

Even fewer studies apply this dynamic approach to graduate migration although it might be particularly relevant for the decision to stay or leave the region of study after graduation. With final exams approaching graduates will start to look for an acceptable job in the university region and beyond, thereby the propensity to out-migrate rises. The pressure to migrate may increase in the course of the residence spell if it turns out that there are not enough adequate jobs and residential opportunities available in the university region. Graduates who are eventually dissatisfied with their first job and/or their life situation in the region of study could also be increasingly willing to leave. In contrast, graduates who already graduated from school in the university region and studied there are supposed to be strongly embedded in region through social networks. Hence, cumulative inertia may determine the migratory behaviour of these resident graduates (Haapanen & Tervo 2012).

There is a voluminous literature on graduate migration. We cannot provide a detailed survey of corresponding studies. Empirical evidence on duration dependence in the context of graduate migration is, however, limited to two studies which use micro-level panel data. A duration analysis for German students by Busch & Weigert (2010) shows that the longer a student lives in the study region the smaller is the probability to move to other German states after graduation. The hypothesis of cumulative inertia is corroborated by a survival analysis of Haapanen & Tervo (2012) for students in Finland. Both studies use information on residence of the graduates on an annual basis. In Germany, 26 percent of the graduates leave the Federal State where they studied up to eight years after graduation. In Finland, 28 percent of the resident students and 51 percent of the non-resident students out-migrate within eight years after graduation. The hazard rates decrease drastically until the fourth year after graduation, after eight years the propensity to out-migrate changes only slightly over time. In case of the Finnish students, a period of three years before the final exams is taken into account additionally. It is shown that out-migration rates increase rapidly in the two years before graduation. This result indicates that the search process for a job, and thus the migration process, starts even before final exams take place. The highest hazard rate is observed in the graduation year.

The empirical literature on graduate migration shows that individual, study-related and regional factors affect the spatial mobility of the young highly educated. Individual characteristics such as sex, nationality, age, and life-cycle effects[1] (having a partner, children and residential property etc.) determine evidently the length of graduate's residence spells in university regions and likely interact with duration dependence.

Human capital factors such as the length of study, the degree, the field of study and the final grade may influence the decision to out-migrate as well. Graduates with good exam grades are supposed to have superior abilities in processing and collecting information, and thus might face lower job search costs (Schultz 1975). As a result, better graduates may search for a job in a larger geographical area and enter the labour market faster after graduation (Schwartz 1976). Residence spells of better students are therefore expected to be shorter. Corresponding evidence is, however, ambiguous showing that better graduates are either more likely to move to other regions or more inclined to stay in the university region (e.g., Haussen & Uebelmesser 2015, Venhorst et al. 2010). In the latter case, it is often argued (e.g., Faggian & Franklin 2014, Venhorst et al. 2010) that the best graduates are the first in the queue for a local job because employers rank the applicants according to expected training costs (Thurow 1975). High-skilled graduates can thus choose among the best local job offers and thereby residential stress for other graduates increases and forces them to extend their job search area beyond the region of study.

Another factor that might interact with duration dependence is location-specific work-experience. However, the literature has largely ignored the relationship between prior working experience and the migration decision of graduates. Some papers address the importance of working experience for finding a job, but ignore the relationship between working experience and mobility behavior (e.g., Venhorst & Cörvers 2015). Social capital approaches (Granovetter 1973) highlight the importance to establish contacts to employers and colleagues during internships and employment episodes. The information provided via such work-related contacts is supposed to help the young high-skilled to find more easily a job (e.g., Klein et al. 2014, Venhorst & Cörvers 2015). As work experience might be gathered in the university region or elsewhere, it may determine migration behaviour after graduation since social networks may facilitate labour market entry in the study region or in other areas. For this reason, we might expect a negative relationship between extra-regional working experience and the length of residence spells.

3. Empirical models

To model the mobility of university graduates, we examine the hazard rate of migration. Formally, the hazard rate $h_i(t)$ is the probability of migration given that the graduate *i* has stayed in the university region up to the period *t* after graduation:

$$h_i(t) = \Pr(T_i < t + 1 | T_i \geq t) \qquad (1)$$

[1] We consider the life-cycle aspect to be of minor importance as most graduates in Germany are presumably still not married and do not have children after graduation.

where T_i is the length of a residence spell in the university region. In the analysis, we use two different definition of migration: a change of the region of residence and labour market entry outside the university region. The first definition is based on an annual information on the residence, while for the second definition we apply information on the exact starting date of an employment relationship and on the location of the corresponding establishment. In the latter case, we define out-migration as taking up a job outside the university region. Hence we assume that the graduates don't commute and also change their residence. Based on this assumption we can observe the exact length of a spell and apply a proportional hazard specification in order to identify important determinants of migration behaviour. In the continuous-time model, the failure is defined as first full-time employment outside the university region after graduation:

$$h_i(t, x_i) = h_0(t) \exp(x_i \beta) \tag{2}$$

where $h_0(t)$ is the baseline hazard and x_i is a vector of influential factors that includes time-varying as well as time-invariant variables. The vector includes individual characteristics such as gender and age of the graduates, information on the studies and the employment biography and characteristics of the regional labour markets. For a detailed description of all explanatory variables see Table A1 in the appendix.

We estimate a parametric model and assume that the baseline hazard ca be described by a Weibull distribution[2]:

$$h_i(t, x_i) = p t^{p-1} \exp(x_i \beta) \tag{3}$$

The regression analysis provides an estimate of the shape parameter p that indicates whether hazard rates increase or decrease exponentially with time.[3]

The data enables us to identify a new workplace location on a daily basis. However, in order to compare our approach with the setting applied in previous duration analyses we also consider changes of the region of residence on an annual basis as in Haapanen & Tervo (2012) and Busch & Weigert (2010). Therefore, we also estimate discrete-time models consistent with the continuous time approach. A complementary log log model is combined with a baseline hazard given by $(\alpha \ln(t))$, the discrete-time analogue of the continuous time Weibull model with $\alpha = p - 1$:

[2] We also estimate a semi-parametric Cox model but do not present the estimates of the Cox regressions in the paper. A disadvantage of the Cox model in the present setting is that the baseline hazard is not parametrized and not estimated, i.e. it does not provide explicit information on duration dependence. The corresponding results are available upon request and closely resemble the estimates from the Weibull model. In particular, the findings regarding work experience turn out to be rather robust. We choose a Weibull distribution because the raw hazards derived from Kaplan-Meyer estimates resemble hazards drawn from a Weibull distribution with $p < 1$ (see Andrews et al. (2011) for a corresponding discussion).

[3] In case of $p = 1$ the model corresponds with an exponential distribution pointing to a constant hazard rate.

$$h_i(t, x_i) = 1 - \exp[-\exp(x_i\beta + \alpha\ln(t))] \quad (4)$$

Again, the baseline hazard provides information on the pattern of duration dependence. However, the estimate of the baseline hazard might be affected by unobserved heterogeneity at the individual level. Therefore, we include a frailty term u_i in the models that captures unobserved heterogeneity. In these models the hazard of an individual is a function of observed characteristics x_i and a latent random effect u_i that enters multiplicatively on the hazard function. It is assumed that graduates differ randomly in a manner that is not fully accounted for by the observed characteristics and that u_i is independent of x_i (see Cameron & Trivedi 2005, chapter 18). Applied to the continuous Weibull model in equation (3) the corresponding shared-frailty model is given by[4]:

$$h_i(t, x_i|u_i) = pt^{p-1}\, u_i \exp(x_i\beta) = pt^{p-1} \exp(x_i\beta + \vartheta_i) \quad \text{with} \quad \vartheta_i = \ln(u_i) \quad (5)$$

With the shared-frailty models we capture within-group correlation and take into account that observations for a given graduate are correlated because they share the same frailty. In other words, the correlation is the result of a latent graduate-level effect. When $u_i > 1$ $(u_i < 1)$ the individual risk of out-migration of graduate *i* is larger (smaller) than for the average graduate. We assume that the young workers have different propensities to migrate and this approach allows us to distinguish between heterogeneity and duration dependence. Without controlling for heterogeneity the estimate of duration dependence is likely downward biased due to sample selection effects (Cameron & Trivedi 2005, Andrews et al. 2011).

A drawback of our approach is that we cannot rule out commuting when using the workplace information to detect moves, i.e. the graduates might take up a job at a firm with a location outside the university region, but they may keep their residence. We try to cope with this problem by using functional regions as regional units, i.e. migration is defined as a move across the borders of functional regions. These regions consist of several NUTS 3 regions which are linked by intense commuting. Thus, commuting first of all takes place within these regions. Moreover, as a robust check, we only consider moves that involve a working place that is at least 150 kilometres away from the university town. Beyond this threshold daily commuting is rather unlikely in Germany. However, long-distance weekly commuting as well as different modes of labour market entry (full-time, part-time, vocational training) may give rise to a significant variation of effects across different definitions of migration.

4. Data

Although there is an extensive literature on graduate migration only a very few studies make use of event history methods to investigate this issue. This is probably due to the fact that these methods are rather demanding regarding the necessary data. Only biographical data

[4] We assume that the heterogeneity can be described by a gamma-distribution.

allows us to precisely identify the date of graduation and observe changes of the residence and the workplace thereafter. Census data and (graduate) surveys usually do not offer such detailed information. A drawback of previous duration analyses of regional migration is that they rely on census and survey data which provide information on the region of residence only on an annual basis. Thus, they cannot differentiate between a move three weeks after graduation and migration one year later.

Our analysis of graduate mobility rests on a unique comprehensive database that combines information from student records of several German universities and from the Integrated Employment Biographies (IEB) of the Institute for Employment Research (IAB). This database enables us to study both graduates' labour market entry and their subsequent careers. As mentioned above, most studies on graduate mobility and labour market entry so far rely on survey data covering mostly career-specific spells and periods. The advantage of our dataset is that a graduate's employment biography includes all spells available in German social security records and is reported until the most current year of the IEB (2014). In addition, spells before and during enrolment at university are reported.

The student records encompass detailed information on students who graduated from three German universities and two universities of applied science. These universities are located in three distinct regions.[5] Usually graduates from all fields of study in which students can enrol are covered by the student records. However, for Giessen University the information is only available for graduates from natural sciences and economics & business administration. The student records comprise information on the duration of study, graduation date, final grade, type of graduation, and field of study. Furthermore, we have information on student's date of birth, gender, nationality and type of university entrance qualification. For our analysis, we only consider the last degree from each graduate's education, i.e. we focus on labour market entry after finally leaving university.

For some graduates mobility after graduation is somehow restricted in Germany. For instance, due to some regulations it is difficult for teachers to take up employment in a publicly-maintained school in another federal state. Moreover, for some individuals important information in the student records is missing. We exclude these groups of graduates from the analysis. We only consider graduates who were less than 35 years old when they finished their studies. And finally we cannot observe the labour entry of the latest cohorts in the IEB. For a comprehensive description of the data preparation see Appendix. The final dataset consists of more than 20,000 graduates.

The IEB provides detailed information on all workers covered by the social security system in Germany, i.e. employees, unemployed persons, job seekers, recipients of social benefits and participants in active labour market programs, on a daily basis from 1975 onward.[6] It is a spell

[5] The universities have two features in common: They are middle-sized (6,000 to 29,000 enrolled students) and they are located in middle-sized university towns. A main difference between both university types is that the former requires a high school diploma and the latter at least an advanced technical college entrance qualification. Moreover, a significant part of the students attending a university of applied sciences have completed a vocational training, and the curricula are mainly application-oriented.

[6] For a detailed description of the IEB see vom Berge et al. (2013).

database that provides a more or less complete picture of the individual's employment biographies. However, civil servants and self-employed persons are not liable to social insurance contributions and therefore not captured in the IEB. Roughly 80 percent of the German workforce is covered by the social security system in Germany.

The database contains starting and ending dates of all job spells of workers on a daily basis. Besides, an establishment identifier and certain job characteristics, such as the wage and occupation, are recorded. Furthermore, information on unemployment spells, benefit receipt, participation in active labour market policies, and job-search status are available.

The student records and the IEB are combined via record linkage by using the following identifiers: first name, surname, date of birth, gender, and nationality. The majority of graduates at each university was successfully matched with the IEB (see Table 1). Hence, we resort to a comprehensive panel database for five medium-sized universities in Germany.

Table 1: **Number of graduates at universities and matching quotes**

University	Student records, Graduation cohorts 1996-2011	Record linkage with IEB	University Panel
	Number of graduates	Number of matched graduates	Matching quote, in percent
Kiel University (CAU)	28,243	23,057	81.6
Kiel University of Applied Sciences (FHK)	4,830	4,650	96.3
Giessen University (JLU)	3,531	3,283	93.0
Saarland University (UdS)	19,456	16,428	84.4
Saarland University of Applied Sciences (HTW)	3,999	3,515	87.9

Migration is mainly defined on the basis of workplace locations in this analysis because this information is available on a daily basis in the integrated employment biographies, i.e. more frequently compared to the region of residence.[7] Information on the region of residence is updated for individuals that receive unemployment and social benefits with the beginning of the corresponding episode. This also applies to graduates who are registered as searching for a job and those who participate in measures of active labour policies. However, for employees the information on the residence comes from the social security notifications of the corresponding firm which are updated only annually. Therefore we rely first of all on the information on the workplace to detect moves. In order to compare the results for different definitions of migration we consider both changes of the workplace location and of the residence.

The analysis is based on information for 16 cohorts of graduates from five German universities who finished their studies between 1996 and 2011. Restricting the dataset in this way, we observe every graduates at least three years after graduation. The final sample includes up to 124,860 spell-day observations for 20,367 graduates. The residence and employment spells

[7] If continuous data is used we only consider employment of at least one year outside the university region as out-migration. Thus, short-term temporary migration, linked e.g. to an internship, is excluded from the analysis.

are monitored until the young worker moves away from the region of studies, the last year of observation being 2014. The maximum observed duration thus amounts to 18 years. This implies that the data is possibly right-censored and that some spells are right-censored at shorter duration. However, allowing for a minimum observation period of three years after graduation should reduce the censoring problem compared to previous studies where the observation ends after only one year after graduation for some workers (see e.g. Haapanen & Tervo 2012, Busch & Weigert 2010).

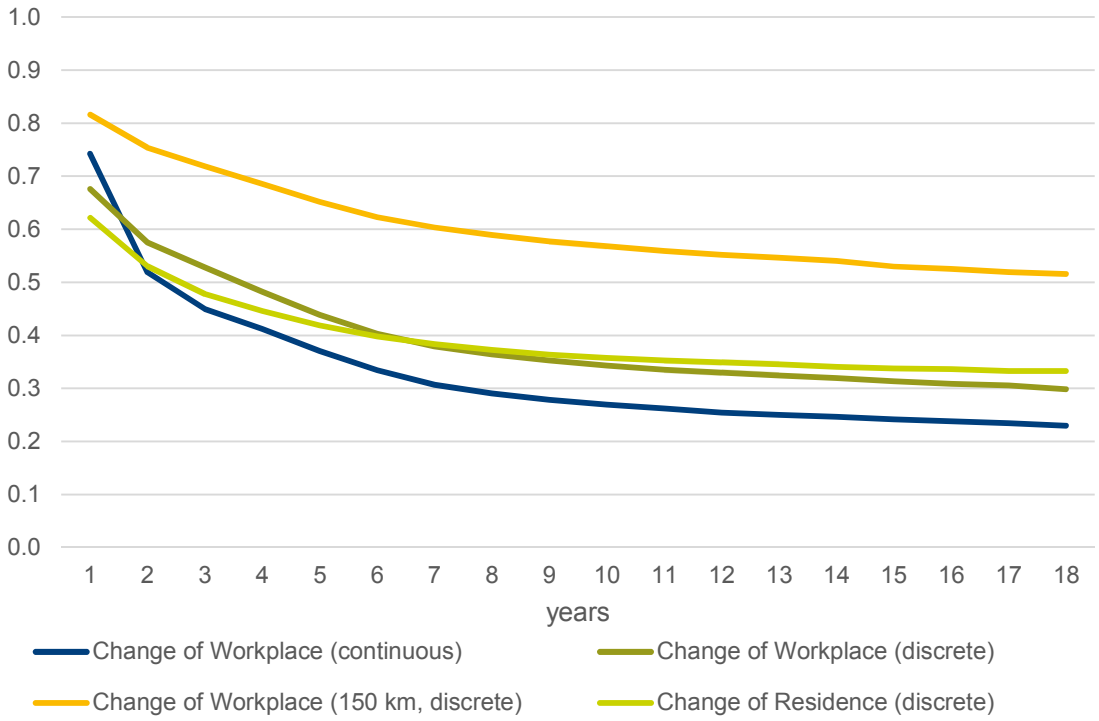
5. Regression results

Figure 1 displays survival functions which base on non-parametric Kaplan-Meyer estimates for different definition of out-migration from the university region. The survival rate gives the probability of staying in the university region until time t after the beginning of the corresponding spell. While there are significant differences in the long-run shares of "stayers", the gradients of the curves are rather similar. All survival functions indicate that the majority of the migration events happen during the first 6 to 7 years after graduation. Afterwards there are only minor changes in the share of stayers. During the first years after graduation, the hazard rates drop rapidly pointing to predominant cumulative inertia. In other words, graduates willing to leave for other regions primarily migrate during subsequent years following final exams. The raw hazards look similar to hazards drawn from a Weibull distribution with a shape parameter $p < 1$.

The long-run share of stayers differs significantly depending on the definition of a move (change of residence, first job outside of university region) and whether we use discrete or continuous data. Apart from the first two years after graduation the range of estimates is determined by estimates that base on continuous workplace data and discrete data applying a minimum distance of 150 km from the university location. Unsurprisingly, the shares of stayers rises if we increase the distance necessary for the event to be considered as a move from leaving a functional region to a distance of 150 kilometres. 18 years after completing their studies around 23% of the graduates never left the region for an employment relationship that lasted more than a year.[8] If the migration event involves a move of at least 100 kilometres, the corresponding percentage amounts to almost 52%. With the latter estimate we should avoid counting daily commuters as migrants.

[8] Using the continuous workplace data we only consider a working period of more than 12 months outside the university region as an out-migration from the functional region where the students completed their studies.

Figure 1: Survivor function (Kaplan-Meyer estimates) – different definitions of migration



Estimates by Busch & Weigert (2010) point to a significantly higher share of stayers among university graduates in Germany. According to their results 68% of the graduates still live in the federal state where they completed their studies 20 years after graduation. The marked variation across estimates is likely caused by different definitions of migration. Busch & Weigert (2010) use information on the residence and rely on federal states, i.e. rather large regional units, to identify migration events. Furthermore, their analysis makes use of discrete data (annual data on the residence). And finally their data set also covers young workers who finished their studies in large agglomerations whereas our focus is on medium-sized university towns and their hinterland. Results by Haapanen & Tervo (2012) for Finnish regions indicate that large urban regions are characterized by higher survival rates. For the Helsinki region survival rates vary between 63% and 83% 13 years after graduation whereas for other regions the percentage of stayers ranges from 34% to 56%.

A comparison of the results for the continuous and discrete workplace data for functional regions suggests that with continuous data the observation of exits, i.e. out-migration to another region, becomes more likely. However, the difference in the share of stayers between the two definitions builds up during the first 3 years after graduation. Afterwards the gap is fairly constant. Interestingly, one year after graduation the share of stayers is higher for the continuous data than for the discrete-time model.[9] Between the first and the third year after graduation a significant difference of approximately 7 percentage points emerges that is more or less constant until the end of the observation period. So it is especially during this early period

[9] These differences might result from the corresponding definitions of out-migration. While we consider employment relationships with a minimum tenure of 12 months as labor market entry outside the university region when using the continuous data, this information is not available in the discrete data. Thus, in the latter case short employment spells of less than one year are also recorded as an out-migration.

after graduation that we detect more exits based on the continuous-time model as compared to the discrete data.

Using the discrete data we observe for some young workers a change of residence before they take up a full-time job outside the university region. For a period of 6 years after graduation the share of stayers is higher for the discrete workplace model as compared to the residence data. The gap between workplace and residence definition might indicate that some graduates first move to another region in order to search for a job on site. In particular, it seems reasonable that unemployed graduates might return back to their home-regions and living with their parents until they have found a job. Moreover, graduates may enter the labour market outside the university region via a part-time job or marginal employment. These moves are not considered in the analysis as our workplace-based definition of migration only considers full-time employment relationships. Commuters may also add to the discrepancy between the curves.

In the long-run the share of stayers is slightly higher if migration refers to a change of residence instead of a workplace outside the university region. Thus, a certain percentage of the graduates decides to permanently reside in university region but at least temporarily works in another region. Altogether the long-run differences in survival rates between these two definitions are moderate, ranging between 2 to 4 percentage points. Using continuous instead of discrete data and varying the minimum migration distance gives rise to more pronounced changes in the share of stayers.

Figure 2: Survivor function (Kaplan-Meyer estimate) – continuous data on workplace location

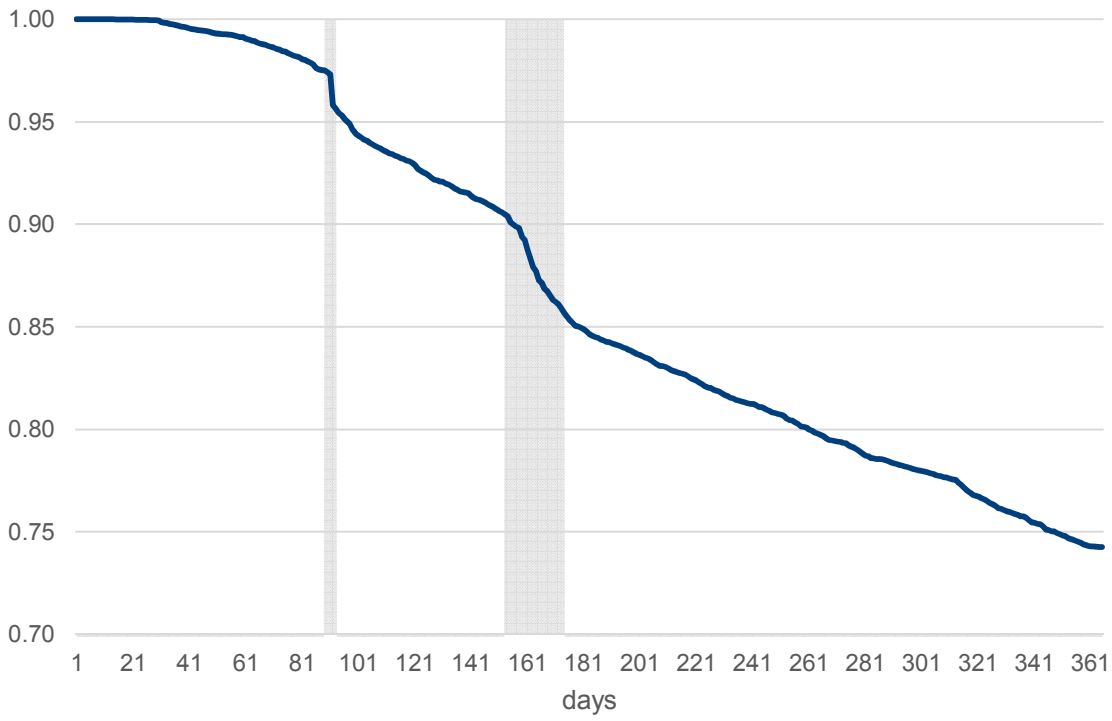


Figure 2 provides some more detailed information labour market entry outside the university region based on the continuous workplace data. The Kaplan-Meyer survival function for the

first year after graduation indicates that the mobility process slowly starts within the first three months after the final exams. Three months after graduation we observe a temporary acceleration which recurs again after approximately five months. However, apart from these discontinuities the survival function describes a rather smooth decline of the share of stayers. Despite a slow start more than 50% of the failures that happen up to one year after graduation take place within the first six months.

Table 2 summarizes regression results for different continuous- and discrete-time models applying a proportional hazard approach. The models (1) to (3) refer to migration as taking up a job outside the (functional) university region, while model (4) also bases on the workplace location, but demanding a move of at least 150 km. Model (5) makes use of annual residence data. All models include individual characteristics of graduates and information on their studies that turned out to be important determinants of the probability to leave to university region in previous analyses. Moreover, some regional characteristics are considered. Apart from model (1) all specifications take into account frailty.

Table 2 around here

While the shape of the raw hazards is rather similar across alternative definitions of out-migration (see Figure 1), there are significant differences between the regression models. This refers primarily to the comparison of workplace- versus residence-based definitions. Although we use functional labour market regions to identify moves or demand a distance of at least 150 km between workplace and university location there are significant differences between the models that base on the workplace location and the residence of the graduate, even if we assume the workplace data to be discrete. In contrast, the variation across models explaining first employment outside the region of studies is altogether moderate. However, estimates of the model that involves a minimum distance of 150 km seem to be a mixture of workplace- and residence-based specifications. The variation across the models suggests that the decision to choose a job outside the study region somewhat differs from the choice of a new residence. In contrast, taking account of unobserved heterogeneity, i.e. comparing model (1) and (2), only gives rise to minor changes of most variables. We will discuss some exception below.

Female graduates tend to manage labour market entry via a full-time job more often in the region of studies than young males, but show a higher probability of choosing a residence outside the region.[10] Differences also show up for age. The variable has a positive but declining impact on the hazard rate of migration if we consider a change of the residence after graduation. This partly confirms results by Haapanen & Tervo (2012), while Busch & Weigert (2010) report a declining probability of out-migration with increasing age of German graduates. In contrast, our results suggest that the probability of job entry outside the university region

[10] It turns out that these differences across models are partly driven restricting the migration event to taking up a full-time job outside the region of study. If we consider all jobs subject to social security contribution, and in particular part-time jobs, no significant differences between male and female graduates show up in the workplace-based models. The corresponding results are available upon request.

does not systematically vary with the age of the graduates. The impact of foreign citizenship does not significantly differ from zero.

Findings on the impact of previous migration experience confirm the results of former studies indicating that mobility at entry to university is highly correlated with post-graduation mobility.[11] However, the information at hand allows us to differentiate between international and interregional migration prior to studies. It turns out that this difference indeed matters for subsequent migration behaviour. While interregional migration, in line with previous evidence, enhances the probability of leaving the region of study, graduates who obtained the university entrance qualification abroad show a lower risk of out-migration. However, for the latter group we detect no important effect on the location of the first full-time job. In contrast, interregional mobility also increases the probability of taking up employment in another region

There is some indication that more successful students, in terms of exam grades, face less problems finding a full-time job in the local labour market as they enter the labour market more often in the region of study compared to graduates with lower grades. However, better grades do not impact on the probability of changing the residence. The estimates (model (2)) indicate that excellent graduates show, ceteris paribus, 10.1% [$1 - \exp(-0.107 \times 1)$] lower risk of taking up a full-time job outside the region of study than very good students. In comparison, graduate who moved to the university region face a hazard 96% greater than graduates who study in their home region. Differentiated effects emerge for the length of study. However, we refrain from a detailed discussion of other study-related factors.[12]

Evidence on the impact of characteristics of the university region is mixed and not robust. Population density and GDP growth seem to influence the location of labour market entry, but not the region of residence. Model (2) indicates that university regions which show high growth tend to show slightly higher retention rates. Our estimates do not confirm the attractiveness of large metropolitan areas for young skilled workers (see e.g. Buenstorf et al. 2016, Krabel & Flöther 2014, Faggian & Franklin 2014). There is also some indication that the share of young inhabitants, income per capita and the unemployment rate matter for post-graduation mobility. The estimates are not robust across specifications and not always in line with previous evidence. However, we do not pay too much attention to the results as our focus is not on the role of regional characteristics. Moreover, in our data the variation of these variables is fairly low because we can only consider graduate limited number of university regions. The employment biography and in particular the work experience gathered prior and during the studies turn out to be important factors that impact on post-graduation mobility. A significant proportion of the young workers has finished a vocational training before starting their studies. These graduates tend to show a lower probability of out-migration than graduates without apprenticeship. However, the two groups do not significantly differ with respect to

[11] Faggian et al. (2007) and Krabel & Flöther (2014) provide corresponding evidence for the UK and Germany, respectively.

[12] In almost all fields of study, hazard rates of migration are smaller than in the reference group, business studies and economics. These effects turn out to be very robust across various specifications and estimators. The university regions under consideration in this analysis seem to be rather unattractive locations for the graduates making up the reference group. Maybe for labour market entry of these young workers the benefits of large urban areas are particularly important, giving rise to high out-migration rates for medium-sized university towns.

the location of labour market entry. If the graduates take up a job at a previous employer, this often coincide with a job inside the university region. And this group of graduates also shows a lower risk of changing the residence.

The effects of work experience turn out to be rather robust across the alternative models and definitions of migration. This applies especially to the work experience gathered during the studies. If the experience refers to jobs outside the university region, taking up a job in another region as well as changing the residence becomes more likely. Extending the experience by 100 days give rise to an increase of the hazard by 41% (workplace) up to 126%% (residence). In contrast, a working period of 100 days within the university region reduces the probability of entering full-time employment in another region by more than 14%.With respect to out-migration we detect an effect of 25%. Experience which was gathered before the studies has a significant but smaller influence on the migration behaviour of the graduates pointing to some kind of depreciation phenomenon, i.e. the importance declines with increasing time lag. Moreover, there is no significant effect of the work experience inside the university region in the continuous workplace model. In contrast, 100 days of work experience before the studies gathered outside the university region increase the likelihood of labour market entry in another region by almost 3%. However, we if consider a change of the residence again opposing effects show up. These differences suggest that work experience reflects labour market contacts, local human capital accumulation, but also social networks, in particular if a change of the residence is concerned.

Table 3 around here

Whether we detect cumulative inertia, cumulative stress or neither of them depend on the definition of out-migration and whether we use discrete or continuous data. With respect to a change of residence neither cumulative inertia nor cumulative stress clearly dominates. We do not detect an important duration dependence. The corresponding shape parameter does not significantly differ from 1, suggesting that the baseline hazard can be described by an exponential distribution which is characterized by a constant hazard rate. This also applies to labour market entry outside the functional region based on discrete data. In contrast, the estimates point to a significant negative duration dependence if we assume a minimum distance of 150 km, probably pointing to the importance of social networks and corresponding migration costs which will increase with the length of the residence spell. The corresponding estimate implies a shape parameter of the Weibull distribution of 0.788 pointing to a moderate negative duration dependence. Andrews et al. (2011) report parameters of similar size for interregional migration in the UK (0.863 for males and 0.857 for females). Haapanen & Tervo (2012) and Busch & Weigert (2010) also provide evidence on a significant duration dependence when residence spells are concerned. It is noteworthy that we actually arrive a positive duration dependence if we used the continuous workplace data. This suggest that the probability of taking up a full-time job outside the university region increases with elapsed time. This result might be driven by graduates who initially search for a job in the region of study, but do not find (adequate) employment and extend their job search area.

Finally we discuss the importance of unobserved heterogeneity. In case of the continuous-time model where the shared frailty is gamma distributed, the estimated frailty variance θ is highly significant, pointing to an important within-group correlation. If we estimate discrete time models with random effects the likelihood ratio tests also indicate that the intra-group correlation ρ cannot be ignored. Comparing the continuous time models with and without frailty suggests that unobserved heterogeneity affects the results for the baseline hazard. In fact, the positive duration dependence increases once we control for unobserved heterogeneity. In Table 3 we compare the corresponding estimates of the discrete time models with and without frailty. The results confirm the finding that the shape parameter of the Weibull distribution is downward biased if we ignore unobserved heterogeneity. This is in line with evidence provided by Andrews et al. (2011).[13] We also display the coefficients for work experience in Table 3. The majority of these effects is smaller in absolute size if we do not consider unobserved heterogeneity.

6. Conclusions

We apply event history methods to investigate graduate migration in Germany focusing on moves that are linked to labour market entry of the young workers. We observe significant changes in the share of stayers up to 7 years after graduation. Thus, focusing on a rather short period after graduation, such as one year, will provide an incomplete picture of post-graduation mobility.

Our results partly confirm evidence provided in similar studies by Busch & Weigert (2010) and Haapanen & Tervo (2012). However, compared to these analyses, the share of stayers is rather low among the graduates considered in our analysis. This might be due to our focus on medium-size university regions which likely suffer from an above average out-migration of young high-skilled workers. Large urban regions might, in contrast, succeed in retaining a relatively high percentages of their graduates. Corresponding results by Haapanen & Tervo (2012) for Finland are in line with this guess.

Individual characteristics, study-related factors and regional characteristics impact on the location of labour market entry and changes of the residence. Moreover, the employment biography influences the decision to leave the region of study. In particular, work experience gathered in- or outside the university regions matters, pointing to the importance of labour market contacts, local human capital accumulation and social networks. As the work experience correlates with individual characteristics and study related factors estimating the effects of these determinants likely results in biased estimates if experience is ignored in the regression model. This also applies to the duration dependence and unobserved heterogeneity. The hazard becomes flatter if we control for unobserved heterogeneity in the model for the change of residence. More precisely, ignoring different individual propensities to migrate results in overestimating the degree of negative duration dependence, in line with evidence provided by Andrews et al. (2011). In contrast, some results for the workplace-based definition of migration point to positive duration dependence. Our results suggest that there is no negative genuine

[13] In contrast, neither Haapanen & Tervo (2012) nor Busch & Weigert (2010) report significant effects of unobserved heterogeneity.

duration dependence when the graduate migration is concerned. It seems that the negative relationship between the probability of leaving the region of study and the length of the residence spell is entirely driven by observed and unobserved graduate characteristics. In contrast, there is some indication for cumulative stress when labour market entry outside the university region is considered.

The findings differ significantly across alternative specifications suggesting that the mobility of graduates is a rather complex phenomenon that is characterized by different combination of changes of residence and workplace. It seems that the estimates for the change of the workplace using discrete data and a minimum distance somehow present a mixture of the findings for the discrete residence model and the continuous workplace approach. So both using discrete versus continuous data and applying information on the residence versus the workplace seem to influence the estimation results. Different combinations of labour market entry outside the university and changes of the residence thus seem to matter. Moreover, we suppose that the sequence of these events is going to vary. This raises important issues for future research and calls for more detailed information on the spatial job search of graduates. With the data at hand we cannot investigate the precise timing of changes of the residence and therefore its interaction with changes of the workplace. High frequency data on both workplace and residence is required in order to shed some light on these issues and examine the role of commuting and in particular long-distance weekly commuting in this context.

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Appendix

Table A 1: Description of explanatory variables

Personal characteristics		
	Female	1 if female, 0 if male
	Age	Age
	Age²	Age squared divided by 100
	Foreigner	1 if foreign graduate, 0 if German graduate
	Mobility before studies	1 if not studying in home region, 0 otherwise
	University entrance qualification abroad	1 if graduate received university entrance qualification abroad, 0 otherwise
Studies		
	Exam grade	From sufficient (1) to excellent (5)
	Study length	Number of semester
	Field of study	• Agricultural sciences • Humanities • Geography/Meteorology • Mathematics/computer science • Medicine/Pharmacy • Natural sciences • Psychology • Law • Social sciences • Business & Economics
	Type of degree	Bachelor, Master/Diploma, other degrees (dummy variables)
	University	CAU, FHK, JLU, UdS, HTW (dummy variables)
Employment biography		
	Vocational training	1 if graduate was undergoing vocational training before studying, 0 otherwise
	Experience (in 100 working days)	• Work experience outside of university region before studies • Work experience within university region before studies • Work experience outside of university region during studies • Work experience within university region during studies
	Previous employer	• 1 if first job after graduation at former employer, 0 otherwise
Regional characteristics (university region)		
	Population density	Population per square metre, in 1,000 inhabitants
	Yearly GDP growth	in percent
	Share 0-24 years old	Share of persons aged 0 to 24
	Income per capita	Primary income of households, in 1,000. Euro
	Unemployment rate	Unemployed as percentage of labour force (in per cent)

Table A 2: Summary Statistics

	Obs.	*Mean*	Std.	*Min.*	Max.
Personal characteristics					
Female	125,443	0.41	0.49	0	1
Age	125,443	30.13	4.35	19	52
Age²	125,443	926.71	282.11	361	2,704
Foreigner	125,443	0.04	0.20	0	1
Mobility before studies	125,443	0.36	0.48	0	1
University entrance qualification abroad	125,443	0.04	0.19	0	1
Studies					
Exam grade	125,443	3.03	0.95	1	5
Study length					
Bachelor degree	125,443	0.53	2.02	0	20
Master degree	125,443	0.23	1.08	0	20
Diploma	125,443	7.95	5.90	0	20
Other degrees	125,443	2.22	4.90	0	20
Field of Study					
Agricultural sciences	125,443	0.05	0.21	0	1
Humanities	125,443	0.15	0.35	0	1
Geography/Meteorology	125,443	0.04	0.20	0	1
Mathematics/computer science	125,443	0.13	0.34	0	1
Pharmacy	125,443	0.04	0.19	0	1
Natural sciences	125,443	0.23	0.42	0	1
Psychology	125,443	0.04	0.19	0	1
Law	125,443	0.05	0.21	0	1
Social Sciences	125,443	0.05	0.22	0	1
Business and Economics	125,443	0.23	0.42	0	1
Type of degree					
Bachelor degree	125,443	0.07	0.26	0	1
Diploma/Master degree	125,443	0.74	0.44	0	1
Other degrees	125,443	0.19	0.39	0	1
Employment biography					
Vocational training	125,443	0.16	0.36	0	1
Experience (in 100 days)					
outside university region, during studies	125,443	0.14	0.57	0	4.47
inside university region, during studies	125,443	1.01	1.27	0	4.52
outside university region, before studies	125,443	2.22	5.04	0	61.58
inside university region, before studies	125,443	6.92	8.12	0	56.73
Previous employer	125,443	0.08	0.27	0	1
Regional characteristics[1]					
Population density	125,443	301.16	97.96	190.13	421.84
Yearly GDP growth	125,443	2.07	3.24	-9.58	5.74
Share of people younger than 24 years	125,443	24.71	1.20	22.06	28.02
Income per capita	125,443	19.05	3.92	12.07	25.79
Unemployment rate	125,443	10.54	1.56	6.6	14.2

Table A 3: Regression results for field of study, type of degree and university

	Change of Workplace						*Change of Workplace- at least 150 km*		*Change of Residence*	
	continuous, without frailty		*continuous, with frailty*		*discrete, with frailty*		*discrete, with frailty*		*discrete, with frailty*	
	coef	*se*	coef	*se*	coef	*se*	coef	*se*	coef	*se*
Field of study (ref: business and economics)										
Agricultural sciences	-0.311**	(0.051)	-0.344**	(0.073)	-0.530**	(0.082)	-0.097	(0.100)	0.167	(0.137)
Humanities	-0.372**	(0.044)	-0.485**	(0.060)	-0.896**	(0.079)	-0.988**	(0.095)	-0.894**	(0.106)
Geography/Meteorology	-0.381**	(0.055)	-0.539**	(0.078)	-0.868**	(0.099)	-0.454**	(0.118)	-0.853**	(0.139)
Mathematics/computer science	-0.314**	(0.039)	-0.368**	(0.057)	-0.455**	(0.062)	-0.412**	(0.079)	-0.778**	(0.096)
Pharmacy	-0.641**	(0.066)	-0.814**	(0.086)	-1.150**	(0.118)	-1.075**	(0.144)	-1.265**	(0.169)
Natural sciences	-0.398**	(0.032)	-0.545**	(0.046)	-0.703**	(0.061)	-0.387**	(0.068)	-0.679**	(0.083)
Psychology	-0.369**	(0.064)	-0.440**	(0.094)	-0.785**	(0.104)	-0.737**	(0.131)	-0.580**	(0.147)
Law	-1.066**	(0.070)	-1.399**	(0.100)	-1.844**	(0.143)	-1.791**	(0.168)	-1.663**	(0.173)
Social Sciences	-0.474**	(0.056)	-0.668**	(0.079)	-1.108**	(0.102)	-0.753**	(0.122)	-1.451**	(0.145)
Type of Degree (ref: Diploma/Master)										
Bachelor	-0.163	(0.112)	-0.236	(0.162)	-0.275	(0.173)	-0.235	(0.228)	-0.177	(0.266)
Other degrees	0.733**	(0.096)	0.797**	(0.130)	0.919**	(0.159)	0.918**	(0.201)	1.375**	(0.244)
University (ref: UdS)										
CAU	2.797	(2.079)	10.699**	(3.431)	-3.887	(3.417)	-3.999	(4.288)	6.079	(4.609)
HTW	-0.349**	(0.044)	-0.475**	(0.063)	-0.517**	(0.069)	-0.665**	(0.088)	-1.168**	(0.107)
FHK	3.017	(2.080)	10.995**	(3.437)	-3.726	(3.419)	-4.409	(4.293)	5.657	(4.611)
JLU	2.665	(2.109)	10.795**	(3.500)	-8.866*	(3.652)	-9.174*	(4.571)	8.764	(4.939)

Notes: * significance at the 0.05 level, ** significance at the 0.01 level; robust standard errors in parenthesis.

Table 2: Regression results - Continuous- and Discrete-Time Duration Models for Change of Workplace/Residence

	Change of Workplace						*Change of Workplace- at least 150 km*		*Change of Residence*	
	continuous, without frailty		*continuous, with frailty*		*discrete, with frailty*		*discrete, with frailty*		*discrete, with frailty*	
	coef	*se*	coef	*se*	coef	*se*	coef	*se*	coef	*se*
Personal characteristics										
Female	-0.070**	(0.023)	-0.108**	(0.032)	-0.153**	(0.037)	-0.091	(0.047)	0.215**	(0.056)
Age	0.009	(0.040)	0.077	(0.058)	-0.022	(0.041)	0.092	(0.047)	0.441**	(0.067)
Age²	-0.002**	(0.001)	-0.003**	(0.001)	-0.000	(0.001)	-0.001*	(0.001)	-0.008**	(0.001)
Foreigner	0.101	(0.061)	0.125	(0.084)	-0.066	(0.088)	-0.143	(0.112)	-0.121	(0.122)
Mobility before studies	0.493**	(0.024)	0.673**	(0.033)	0.809**	(0.051)	0.834**	(0.057)	2.702**	(0.111)
University entrance qualification abroad	-0.087	(0.068)	-0.061	(0.095)	-0.179	(0.103)	-0.135	(0.130)	-1.164**	(0.151)
Studies										
Exam grade	-0.067**	(0.013)	-0.107**	(0.018)	-0.083**	(0.021)	-0.016	(0.026)	0.048	(0.031)
Study length										
Bachelor degree	0.054**	(0.012)	0.054**	(0.018)	0.028	(0.020)	0.015	(0.026)	0.027	(0.031)
Diploma	0.007	(0.005)	-0.003	(0.007)	-0.007	(0.007)	-0.036**	(0.009)	-0.041**	(0.011)
Master Degree	0.089**	(0.013)	0.084**	(0.019)	0.038	(0.020)	0.054*	(0.026)	0.005	(0.031)
Other degree	-0.034**	(0.007)	-0.050**	(0.009)	-0.067**	(0.011)	-0.090**	(0.014)	-0.108**	(0.017)
Employment biography										
Vocational training	0.049	(0.035)	0.054	(0.050)	0.055	(0.056)	-0.172*	(0.074)	-0.321**	(0.090)
Experience (in 100 days)										
outside univ. region, during studies	0.185**	(0.015)	0.345**	(0.024)	0.396**	(0.033)	0.178**	(0.032)	0.815**	(0.053)
inside univ. region, during studies	-0.113**	(0.010)	-0.154**	(0.013)	-0.164**	(0.017)	-0.145**	(0.021)	-0.291**	(0.025)
outside univ. region, before studies	0.022**	(0.002)	0.029**	(0.003)	0.022**	(0.004)	0.013**	(0.005)	0.058**	(0.006)
inside univ. region, before studies	0.006**	(0.002)	0.004	(0.002)	-0.008**	(0.003)	-0.018**	(0.004)	-0.044**	(0.005)
Previous employer	-0.039	(0.037)	-0.151**	(0.051)	-0.018	(0.062)	-0.412**	(0.083)	-0.469**	(0.098)
Regional characteristics[1]										
Population density	0.012	(0.009)	0.047**	(0.014)	-0.036*	(0.015)	-0.033	(0.018)	0.038	(0.020)
Yearly GDP growth	-0.007	(0.005)	-0.020*	(0.008)	0.015*	(0.007)	0.013	(0.008)	-0.001	(0.008)
Share of people younger than 24 years	0.162	(0.123)	-0.134	(0.203)	1.209**	(0.237)	0.938**	(0.291)	-0.247	(0.311)

	Change of Workplace						*Change of Workplace- at least 150 km*		*Change of Residence*	
	continuous, without frailty		*continuous, with frailty*		*discrete, with frailty*		*discrete, with frailty*		*discrete, with frailty*	
	coef	*se*	coef	*se*	coef	*se*	coef	*se*	coef	*se*
Income per capita	-0.048	(0.059)	-0.113	(0.091)	-0.751**	(0.071)	-0.663**	(0.085)	0.332**	(0.086)
Unemployment rate	-0.144**	(0.010)	-0.255**	(0.019)	0.066**	(0.016)	0.069**	(0.020)	0.111**	(0.024)
Ln(*p*)	*0.100***	*(0.009)*	*0.190***	*(0.078)*	-0.126	(0.083)				
θ			*0.433*	*(0.021)*						
Ln(t)							-0.212**	(0.075)	-0.000	(0.068)
Implied *p*	*1.106*	*(0.010)*	*1.542*	*(0.032)*	*0.874*		*0.788*		*1.000*	
LR test of ρ = 0 (p-value)					*211.75 (0.00)*		*182.28 (0.00)*			
Log Likelihood	-25,466		-25,234		-27,786		-24,182		-23,222	
Number of students	20,394		20,394		20,394		20,394		20,394	
Observations	125,443		125,443		80,833		108,196		82,451	

Notes: [1]: university region; ref: reference; * significance at the 0.05 level, ** significance at the 0.01 level; robust standard errors in parenthesis. All models include time fixed effects, university, field of study and type of degree dummies.

Table 3: Duration dependence and the effect of work experience in discrete time models

	Change of Workplace				*Change of Residence*			
	without frailty		*with frailty*		*without frailty*		*with frailty*	
	coef	*se*	coef	*se*	coef	*se*	coef	*se*
Experience (in 100 days)								
outside univ. region, during studies	0.192**	(0.013)	0.396**	(0.033)	0.215**	(0.013)	0.815**	(0.053)
inside univ. region, during studies	-0.094**	(0.010)	-0.164**	(0.017)	-0.118**	(0.010)	-0.291**	(0.025)
outside univ. region, before studies	0.010**	(0.002)	0.022**	(0.004)	0.017**	(0.002)	0.058**	(0.006)
inside univ. region, before studies	-0.007**	(0.002)	-0.008**	(0.003)	-0.020**	(0.002)	-0.044**	(0.005)
Ln(t)	-0.838**	(0.022)	-0.126	(0.083)	-1.139**	(0.023)	-0.000	(0.068)
Log Likelihood	-27,892		-27,786		-23,912		-23,222	
Number of students	20,394		20,394		20,394		20,394	
Observations	80,833		80,833		82,451		82,451	

Notes: * significance at the 0.05 level, ** significance at the 0.01 level; robust standard errors in parenthesis.