Regional Clustering of Human Capital - School Grades and Migration of University Graduates*

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Abstract

The spatial distribution of human capital plays a fundamental role for regional differences in economic growth and welfare. This paper examines how individual ability indicated by the grade point average (GPA), from comprehensive school, affects the probability of migration among young university graduates in Sweden. Using detailed micro data available from the Swedish population registers, the study examines two cohorts of individuals who enrol in tertiary education. The results indicate that individual abilities reflected by the GPA are strongly influential when it comes to completing a university degree and for the migration decision after graduation. Moreover, there is a positive relationship between the GPA and the choice of migrating from regions with a relatively low tax base and a relatively small share of highly educated people in the population. Analogously, individuals with a high GPA tend to stay at a higher rate in more flourishing regions.

Keywords: Bivariate probit; individual ability; migration; regional clustering; university graduates
JEL Classification: I23; J24; R23

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1 Introduction

Regional concentration of highly educated individuals to cities is an ongoing trend in many developed countries. This may in turn have important consequences in a longer time-perspective, since the availability of human capital typically affects economic development and growth (see, e.g., Lucas, 1988; Barro and Sala-I-Martin, 2004). A larger share of university graduates in a region positively affects the productivity of a plant, suggesting a spill-over effect in the share of the highly educated (Moretti, 2004a). In another study by Moretti (2004b), where he allows for higher levels of unobserved ability in regions with a larger share of university graduates, he finds that an increased share of university graduates have positive effects on salaries for all types of education levels. A larger concentration of human capital to the already wealthy urban areas of a country will therefore disfavour growth in the more economically depressed regions and may lead to cumulative effects on regional discrepancies in the standard of living (e.g., Ozgen *et al.*, 2010). As fewer university-educated people choose to stay in rural regions, these places will lose not only human capital but will also experience a diminishing tax base and increasing difficulties in the provision of public services. Abel and Deitz (2011) find only a small correlation between the stock and the production of human capital in a region; it is rather the migration patterns that will play a significant role for the regional composition of human capital.

Previous research on regional migration and education usually focuses on the correlation between higher education and regional migration, and shows that migration rates increase with university education (see, e.g., Molho, 1987; Hughes and McCormick, 1989; Antolin and Bover, 1997; Ritsilä and Ovaskainen, 2001). Furthermore, studies on location choice indicate that a majority of highly educated individuals tend to choose to live in cities and urban areas (see, e.g., Costa and Kahn, 2000; Pekkala, 2003; Ritislä and Haapanen, 2003). Studies on migration behaviour of recent university graduates point to similar results. Haapanen and Tervo (2012) find when studying university graduates in Finland, there is higher out-migration of graduates from more peripheral universities compared to graduates from the Helsinki region, suggesting that there's a brain drain of highly educated from the more rural regions. Bjerke (2012) studies Swedish university graduates and finds similar results that declining regions has difficulties to attract graduates. Furthermore, the characteristics for the region of graduation are of importance for the migration decision. Studies on British and Australian graduates confirm this trend, i.e. cities are more attractive compared to rural areas (see, e.g., Faggian and McCann, 2006, 2009; Concoran *et al.*, 2010). In the Australian case, the retention rates of the cities are higher compared to more rural areas, even though wages are higher in the rural areas suggesting that the

cities are especially attractive for this education group.[1] Since the labour market for the highly educated is usually more specialized, the probability of finding a job that matches their education is usually higher in cities. In cities and more densely populated areas, certain types of public goods and amenities are present at a larger extent compared to rural regions.

The purpose of this paper is to study migration and regional sorting of human capital in Sweden by individual grade point average (GPA) and regional economic attributes. Previous related studies have focused primarily on explaining migration by education levels, or migration behaviour conditional on a specific level of educational attainment. This study controls for heterogeneity within the group of university graduates by including GPA and treats graduation from higher education and migration as two simultaneous outcome variables that are driven by individual ability. One such indicator of ability is the GPA from compulsory school, which will be used in the analysis below. To be more specific, a large data set comprising individuals born in 1974 and 1976, respectively, is used to examine how individual characteristics affect the probability of having completed a university degree at age 25 and the probability of migrating to another labour market area (LMA) between the ages 25-30. As such, the present paper provides a complement (and a continuation) to a study by Berck, Tano and Westerlund (2014) which examines location choices of the same individuals earlier in life. Their results point to the importance of GPA concerning the decision to invest in further education, and (re)location decisions when leaving secondary school. Notice that the GPA will catch some of the heterogeneity in productivity between the individuals, but not all. The relationship between GPA and ability will be discussed in the next section. The possible correlation between unobserved heterogeneity affecting graduation and the subsequent migration is considered and tested explicitly in the statistical analysis.

In addition to the direct effects of ability on graduation and migration, the present study also examines the interaction effects between the individual's GPA and regional characteristics. Of particular interest is the question of whether migration contributes to a systematic selection of individuals with higher GPA into regions with higher tax bases. Another contribution compared to previous studies on migration of the highly educated is the richness of data, which enables controlling for parents' location and education. Furthermore, data on two entire cohorts are used to check the stability of the results.

The results indicate a positive significant effect of the individual's GPA on the migration decision. The regional characteristics are also of importance; individuals located in regions with a higher tax base per capita, a higher share of university educated people, and more densely populated areas have a lower probability of migrating.

[1] This is consistent with the theory of compensated wage differentials.

In the next section, the theoretical framework is presented. The data is described in section 3. In section 4 the econometric model and hypotheses are outlined. The results and robustness checks are found in section 5, while section 6 concludes the study.

2 Theoretical Framework

Migration theory, based on utility comparison between locations, dates back to the work of Sjaastad (1962). The individual is assumed to maximize his/her utility where migration will take place when the utility of residing in a different region is greater than the utility of residing in the current region, subtracting away the costs of migration. Due to heterogeneity among the individuals, the individuals will face different net benefits (monetary or non-monetary) of living in a specific region. This could be due to different employment opportunities in a specific location, or simply that the individuals have different utility functions. The utility comparison is evaluated at the net present value of the benefits of living in another region compared to the current region. This means, for example, that the propensity to migrate will decrease with age, since the time period of discounting future benefits will be shorter. Individuals with higher education will also be more prone to migrate since it could potentially benefit them more by finding a more specialized job in another location. The same reasoning can be applied to individuals with higher GPA; they might hold special skills that will increase their possibility of finding a job elsewhere. Individuals with a higher education might also have a comparative advantage in searching and processing information about jobs in other locations.

Previous research has shown that the characteristics of the region of residence are important when modelling the migration decision (see, e.g., Greenwood, 1985; Ritsilä and Ovaskainen, 2001; Bjerke, 2012). Three regional characteristics of the original region are taken into account in the models estimated in the present study; namely the share of highly educated individuals, population density, and the tax base per capita. The first two attributes are assumed to be especially important for university graduates, where dense labour markets with a higher skill level of employment offer more attractive job opportunities and better career prospects for the highly educated, which smaller and less diverse labour markets cannot provide (see, e.g., Glaeser and Maré, 2001). Higher per capita tax base indicates better economic prospects in general and may also reflect a richer supply of public goods (or private goods provided by the local/regional public sector). Certain types of cultural production may be especially attractive for the highly educated, but can rarely be provided in regions with low tax bases which struggle to finance basic provision of health care, education, and culture as required by national law. Geographical

closeness to family members has been shown to be important for migration/location decisions. Mincer (1978) was the first to discuss how regional family ties discourage migration. Later studies by, e.g. Mulder (2007), have confirmed the importance of family members' location when modelling the migration decision. Migration behaviour in the past has also been found to influence the migration propensity, since it indirectly reflects attachment to a region. University graduates who have migrated prior to their university education are also more likely to migrate after graduation (see, Kodrzycki, 2001; Haapanen and Tervo, 2012). The location of the parents and the previous migration variable will give an indication if the individual resides in their LMA of birth, which captures some of the attachment to the region of residence.[2]

2.1 GPA and Ability

This study is based on the assumption that the GPA serves as a latent indicator of individual ability. There are previous studies using different indicators of ability to explain, e.g. income later in life, non-academic success, and returns to schooling. Some of them measure latent cognitive ability by using test scores in explaining different labour-market outcomes (see, e.g., Griliches and Mason, 1972; Boissiere *et al.,* 1985; Heckman *et al.,* 2006). In the context of using GPA from comprehensive school to show labour market outcome later in life, Wikström and Wikström (2011) study the return to education for Swedish students using the same GPA from year 9 as in this study. They find that the returns to education for university graduates are higher for students who belong to the top quartile of the GPA distribution. However, moving down the GPA quartile distribution, the returns to education decreases. This applies both to individuals who continues with university education and those who do not, suggesting that GPA, to an extent, reflects the ability and the productivity of the individual. Studies on returns to college education using GPA from college also show that individuals with higher GPA obtain higher incomes later in life (see, e.g., Wise, 1975; Jones and Jackman, 1990; Loury and Garman, 1995). Glaser and Maré (2001) study the relationship between ability, measured by military test scores and income among city residents and residents of rural areas. When controlling for the test scores, the wage gap between cities and rural areas is still positive, suggesting a wage premium effect of the city. They find that the test scores reflect about one-third of the wage gap.

[2] 91% of the parents stay in the same LMA as when the individual attended high school and 87% as when the individual was 6 years old.

3 Data

The analysis is based on longitudinal data from the Linnaeus Database at Umeå University.[3] It originates from various population registers administrated by Statistics Sweden and includes information on the individual, as well as their partners and parents. Indicators of regional characteristics are taken from official statistics provided by Statistics Sweden (SCB). Data refers to all single-household individuals belonging to two birth cohorts: 1974 and 1976, who reside in Sweden between the ages 25 and 30.[4] Migration behaviour of singles compared to couples may differ since in the latter case, there are two individuals involved in the decision process. This paper will focus on the singles' decision to migrate for two reasons. First, the share of individuals married or cohabiting with a child at age 25 in this sample is quite low. The couple formation process usually takes place later in life.[5] Second, it is easier to accurately model the migration decision given the available data when there is only one person's utility to maximize.

The measure of the individual's GPA used in this study is based on all subjects from the ninth grade, which is the final year of compulsory school in Sweden. This measure is a more homogenous measurement compared to GPA from upper-secondary school where the GPA differs depending on the different high school programs which do not include the same subjects for all individuals. An additional criterion to be included in the sample is that the individual had graduated from a high-school program and was enrolled in higher education at a university by age 23. They were considered participating in higher education if they received student benefits during any year between ages 19 and 23.[6] The selection process into higher education is not of importance here; the focus is on the migration decision for a given level of education. The total sample amounts to 43,491 individuals for the cohort born in 1974 and 45,397 individuals in the younger cohort. The two cohorts were chosen for two reasons. Firstly, the 1974 cohort is the first cohort for which we have information available on the GPA from the ninth grade. Secondly, data is only available up to the year 2006, the year when the 1976 cohort reached the age of 30. The cohorts also differ from each other since they entered university education under different macro-economic conditions. The first cohort finished high school in a more unstable labour market; unemployment was rising due to the financial crisis in Sweden in the early nineties,

3 The data in this study has restrictive public use. For detail description on the data base, see Bonita *et al.* (2011)

4 Singles are defined as non-married or cohabitating without children. The data does not allow for a distinction between cohabitating couples without children and single households.

5 90.1 % are registered as singles at age 25. Two years later the percentage has decreased to 82.1 % indicating that couple formation at a large extent happens later for the highly educated.

6 All students are entitled to benefits. A part of the benefits does not constitute a loan, and is usually claimed by all individuals engaged in higher education.

while for the second cohort, the labour market was relatively more stable with increasing employment.

The econometric model to be estimated includes two dependent variables. One is an indicator of graduation from a university (*Grad*). It is equal to 1 if the individual had completed a university degree by age 25, and zero otherwise.[7] The other indicates migration between age 25, the year of the potential graduation, and age 30 (*Migration*). The definition of migration used in this study is a change of LMA between the years of observation defined above. The LMAs consist of 87 regions created by the Swedish Statistics (SCB) and are based on the observed commuting patterns between the Swedish municipalities. The reason for using LMAs instead of municipalities is to address job-related migration instead of a change of residence only. Individuals can, for example, migrate to a smaller municipality within an urban region but still not change jobs. The five-year gap allows the individuals to have made their final choice of location after finishing their education. Furthermore, mobility decreases with age and migration rates between regional labour markets after age 30 tend to be very low.

The explanatory variables of main interest are the grade point average (*GPA*) from the ninth grade and regional characteristics, i.e., the per capita tax base (*Tax Base*), population density (*Density*), and share of the regional population with high educational attainment (*Highly Educated*). Individual attributes that will be controlled for include: gender, children, foreign-born status, year of enrolment in university studies, migration history, and the parents' location and their education. Both the personal and the regional variables are measured when the individual is 25 years old, i.e. in 1999 and 2001, respectively, except for previous migration which is measured between the ages 19 and 25.[8] Formal definitions of the variables are presented in Appendix table A1. The models to be estimated allow for interaction effects between the regional variables and the GPA. These interaction effects indicate whether or not individuals with a high GPA already living in thriving/urbanized regions tend to stay there. The descriptive statistics of the personal characteristics by migration status can be found in Table 1. The table indicates higher means of GPA for migrants, and also relatively lower proportions of highly educated, lower density, and lower per capita tax bases in the regions were they resided before migration. Migration rates are around 24% between the age 25 and 30. The share of individuals that have received a university degree by age 25 is 65% for the older cohort and 68% for the younger cohort.

[7] At least 2 years of post-secondary education are recognized as university degrees.

[8] The per capita tax base increased on average by 10 % and the share of highly educated by 8%. Further the standard deviation of the regional variables increased.

Table 1. Sample means of individual and regional attributes by migration status.

Cohort:	**1974**		**1976**	
Variables	***Migrants***	***Non-migrants***	***Migrants***	***Non-migrants***
G.P.A	3.61	3.52	3.58	3.51
Females	0.51	0.53	0.52	0.54
Unemployed	0.19	0.20	0.20	0.21
Highly educated father	0.36	0.32	0.36	0.33
Highly educated mother	0.41	0.37	0.41	0.37
Previous Migration	0.58	0.29	0.60	0.28
Parents in same location	0.43	0.72	0.41	0.72
Finishing University	0.74	0.64	0.76	0.66
Children	0.04	0.09	0.03	0.09
Foreign born	0.07	0.05	0.06	0.07
Highly Educated	8.2	9.3	10.1	11.4
Density	153.2	280.2	152.1	272.2
Tax Base	99.2	103.1	109.3	113.5
N	11213	34000	11501	35014

Note: The definitions and units of measurement of the variables are found in table A1.
Thedensity is logged in the estimations.

Similar to many other OECD countries during the 1990s, the Swedish education system was greatly expanded. The expansion was both in form of increased expenditures by 30% between 1993 and 2001, a general increase in the number of admission places, and by the establishment of new Universities and Colleges in regions outside metropolitan areas and pre-existing university towns (OECD, 2006). The expansion in the 1990s granted many universities the right to conduct research and offer longer study programs. Two major consequences followed this expansion: first, that the number of full-time university students doubled between 1989 and 1999 and, second, the migration rates among individuals investing in higher education increased (see Holzer, 2007).

4 The Econometric Model

A bivariate probit model is used to estimate the two outcomes: having a university degree at age 25 and migration between 25 and 30. This approach is suitable when analyzing: (i) two outcomes that are driven by interrelated processes, (ii) the unobserved heterogeneity is systematically correlated across equations, and (iii) the latent propensities to graduate and migrate are not directly observable. Instead, the data provides information on the dichotomous outcomes whether the individual graduated or not and whether she moved or not. The bivariate probit is more efficient compared to two univariate probit models when the unobserved heterogeneity is systematically correlated between equations (Greene, 2008). An individual who graduates may

have unobservable characteristics that also affect the probability of migrating, which is taken into account and tested in the bivariate probit model. The bivariate probit model is more flexible than a bivariate logistic in the sense that the latter imposes a restriction on the correlation between the error terms (Smith and Moffitt, 1999). The model to be estimated is a full observability model, i.e. migration or not is observed independently of whether or not the individual graduated. A major reason for not using a partial observability model, or conditioning the sample on graduation, is that students close to graduation quite often take a job and migrate before getting their final exam. Many of these students graduate within a couple of years and there is substantial variation in the GPA within this group. The latter is also true for the group of early drop-outs. This is also confirmed in the study by Haapanen and Tervo (2012) where they find that two years before and up to graduation, the migration rates are decreasing and tend thereafter to level off. For these reasons, the chosen econometric approach is favoured over the alternative of using a partial observability model, e.g. van de Ven and van Praag (1981).

The bivariate probit model can be specified as:

$$Y_{1i}^{*} = \alpha_1 + \beta_1 X_i + \delta_1 Z_i + \gamma_1 W_i + \varepsilon_{1i} \qquad Y_{1i} = \begin{cases} 1 \; if \; Y_{1i}^{*} > 0 \\ 0 \; if \; Y_{1i}^{*} \leq 0 \end{cases} \qquad (1)$$

$$Y_{2i}^{*} = \alpha_2 + \beta_2 X_i + \delta_2 Z_i + \gamma_2 W_i + \varepsilon_{2i} \qquad Y_{2i} = \begin{cases} 1 \; if \; Y_{2i}^{*} > 0 \\ 0 \; if \; Y_{2i}^{*} \leq 0 \end{cases} \qquad (2)$$

and

$$\text{Cov}\left[\varepsilon_{1i}, \varepsilon_{2i}\right] = \rho \qquad (3)$$

where i ($i=1,....N$) denotes the individual. Y_{1i} is the dichotomous dependent variable indicating whether or not the individual has completed tertiary education and Y_{2i} is the second dependent variable indicating whether or not the individual migrated. Y_{1i}^{*} and Y_{2i}^{*} are the corresponding latent index variables. The vectors $\mathbf{X_i}$ and $\mathbf{Z_i}$ measure personal characteristics and regional characteristics, respectively. $\mathbf{W_i}$ represents interaction variables between the GPA and the regional characteristics.[9] Equation (1) and Equation (2) are interpretable in terms of a reduced form of a simultaneous system, which explains why the same set of explanatory variables is used

9 Only one interaction variable is estimated in each specification due to multicollinearity.

in both equations (see Greene, 2008).[10] A reduced form approach is motivated because we are primarily interested in estimating the effect of the GPA and the regional variables on the two outcome variables, not in capturing the mechanisms of the underlying structural form. Equation (3) shows the correlation between the error terms in the bivariate probit model captured by the parameter ρ. If this parameter differs from zero, the error terms in the two equations are correlated and indicate that the bivariate probit model yields more efficient estimates than using two separate univariate probit models. A significant parameter estimate of ρ, different from zero, also confirms that the unobserved heterogeneity affecting the probability of graduating and the probability of migration are correlated.

There are essentially three hypotheses that will be tested in this study. *Hypotheses:* 1) All else equal, the higher the GPA the higher the probability of migration, $\beta_{2\,\mathrm{GPA}} > 0$; 2) Individuals already living in a region with a higher population density, higher share of highly educated individuals and a larger tax base will be less likely to migrate, $\delta_2 < 0$; 3) Individuals with higher GPA and who are already living in region with higher per capita tax base, population density, and share of highly educated will be less likely to migrate, $\gamma_2 < 0$.

5 Results

Tables 2.1 and 2.2 show the estimation results for the two cohorts with four different specifications.[11] The difference between the two cohorts is not significant, but the results of both cohorts are kept to show stability across cohorts.[12] The difference between the specifications is confined to covariates capturing interaction effects. Specification (1) does not include interaction variables, while in specification (2), the *GPA* is interacted with *Density*. Specification (3) includes interaction between *GPA* and *Tax Base,* and specification (4) allows for interaction effects between *GPA* and *Highly Educated*. The reason for not including all interaction effects in the same specification is due to problems with multicollinearity and convergence. The issue of multicollinearity between the regional variables *Density* and *Highly Educated* is discussed and tested through a robustness check in section 5.2. Estimated effects of parameters pertaining to some of the personal covariates, i.e. *Female, Children, Starting year of studies, Unemployed* and *Foreign born,* are not displayed in the table.[13]

[10] This means that variables that seem to affect only one outcome are included in both equations, e.g. parents' education which do not directly influence the probability of migration.

[11] The correct prediction for both dependent variables in this model is roughly 60%. Failing to predict correctly for both equations only happens in 4% of the cases. The percentage of corrected predictions does not change between different specifications.

[12] The exception is for the GPA estimate when including the interaction effects, where there is a significant difference between the cohorts on the 5 % level.

[13] This is due to space issues; the estimates are available upon request.

Table 2.1. Bivariate Probit Estimates, cohort 1974

Dependent Variable: Migration	**(1)**	**(2)**	**(3)**	**(4)**
GPA	**0.1022****	**0.5384****	**1.2829****	**0.4214****
Parent in location	**-0.4222****	**-0.4312****	**-0.4264****	**-0.4298****
Previous migration	**0.4247****	**0.4161****	**0.4199****	**0.4165****
Highly educated mother	**0.1065****	**0.1071****	**0.1065****	**0.1081****
Highly educated father	**0.1123****	**0.1163****	**0.1144****	**0.1156****
Highly Educated	**-0.0717****	**0.1076****	**-0.0696****	**-0.0700****
Tax Base	**-0.0060****	**-0.0050****	**0.0358****	**-0.0052****
Density[¤]	**-0.1687****	**-0.1676****	**-0.1684****	**0.0794***
Interaction Highly Educated and GPA		**-0.0506****		
Interaction Tax Base and GPA			**-0.1172****	
Interaction Density and GPA				**-0.7043****
Dependent Variable: Grad				
GPA	**1.1093****	**1.1032****	**0.7655****	**1.1233****
Parent in location	**-0.2048****	**-0.2048****	**-0.2038****	**-0.2051****
Previous migration	**0.1985****	**0.1985****	**0.1996****	**0.1981****
Highly educated mother	**0.1111****	**0.1779****	**0.1111****	**0.1111****
Highly educated father	**0.1779****	**0.1111****	**0.1773****	**0.1781****
Highly Educated	**0.0322****	0.0299	**0.0316****	**0.0323****
Tax Base	**0.0040***	**0.0035***	-0.0080	**0.0035***
Density[¤]	**-0.1168****	**-0.1168****	**-0.1164****	**-0.1067****
Interaction Highly Educated and GPA		0.0070		
Interaction Tax Base and GPA			**0.0338***	
Interaction Density and GPA				-0.0291
Personal control variables	**yes**	**yes**	**yes**	**yes**
Rho (ρ)	**0.0473****	**0.0469****	**0.0476****	**0.0469****
N	43491	43491	43491	43491

**, * indicates significance at 1% and 5% level respectively. The density variable is logged in all estimations.

Table 2.2. Bivariate Probit Estimates, cohort 1976

Dependent Variable: ***Migration***	**(1)**	**(2)**	**(3)**	**(4)**
GPA	**0.1056****	**0.4075****	**1.0076****	**0.3090****
Parent in location	**-0.4373****	**-0.4420****	**-0.4388****	**-0.3174****
Previous migration	**0.4468****	**0.4424****	**0.4451****	**0.4433****
Highly educated mother	**0.1128****	**0.1140****	**0.0929****	**0.1136****
Highly educated father	**0.0919****	**0.0938****	**0.1135****	**0.0937****
Highly Educated	**-0.0500****	**0.0495****	**-0.0487****	**-0.0493****
Tax Base	**-0.0077****	**-0.0072****	**0.0210****	**-0.0074****
Density¤	**-0.1551****	**-0.1542****	**-0.1551****	0.0032
Interaction Highly Educated and GPA		**-0.2848****		
Interaction Tax Base and GPA			**-0.0869****	
Interaction Density and GPA				**-0.4518****
Dependent Variable: ***Grad***				
GPA	**1.2493****	**1.4447****	**1.7478****	**1.3417****
Parent in location	**-0.1979****	**-0.1995****	**-0.1828****	**-0.1987****
Previous migration	**0.2673****	**0.2664****	**0.2672****	**0.2668****
Highly educated mother	**0.1688****	**0.1696****	**0.1694****	**0.1692****
Highly educated father	**0.1821****	**0.1831****	**0.1827****	**0.1827****
Highly Educated	**0.0256****	**0.0852****	**0.0262****	**0.0260****
Tax Base	**-0.0057****	**-0.0055***	**0.0093****	**-0.0057***
Density¤	**-0.0813****	**-0.0813****	**-0.0818****	0.0162
Interaction Highly Educated and GPA		**-0.1765****		
Interaction Tax Base and GPA			**-0.0443****	
Interaction Density and GPA				**-0.1943*****
Personal control variables	**yes**	**yes**	**Yes**	**yes**
Rho (ρ)	**0.0659****	**0.0652****	**0.0652****	**0.0656****
N	45397	45397	45397	45397

**, * indicates significance at 1% and 5% level respectively. The density variable is logged in all estimations.

The estimated effect of the *GPA* is positive and significant for the probability of migration, providing support for hypothesis 1. The estimated effects of the regional variables *Share of Highly Educated, Density,* and *Tax Base* supports hypothesis 2; out-migration is lower from regions with a high share of *Highly Educated*, higher *Density* and higher *Tax Base*, respectively, all else equal.[14] The results pertaining to the interaction variables indicate regional selection of individuals with higher GPA to relatively more "well off" regions. All estimates of the interaction effects are negative and significant suggesting that students with high GPA, who reside in regions characterized by a strong tax base, high population density, and/or a well

[14] This is at least true when not including an interaction variable, when included the total marginal effects must be calculated to see the full effect of the regional variables.

educated population, are less likely to migrate. Here, the null hypothesis could be rejected, suggesting that the estimates of γ_2 are negative, supporting hypothesis 3. Note also that the estimate of ρ is positive and significant for all specifications. This result suggests that the unobserved factors affecting the probability of completing a university degree and the probability of migrating are positively correlated. Furthermore, it confirms that using a bivariate probit model provides gains in efficiency compared to two independent probit models.

In line with expectations, there is a strong discouragement to migrate if one has a parent living in the same region, and a higher probability of migrating if one has previously migrated. Although the results confirm that the individual's GPA and the regional characteristics have a statistically significant impact on the decision to migrate, the magnitudes are not shown here. The estimated marginal effects of the joint probability of migration and finishing a university degree are given in table 3.

The marginal effects are calculated according to the parameter estimates in table 2.1. and 2.2, where the effects of the continuous variables are evaluated at their means, and show the change in the joint probability when increasing the covariate by 10%. In column (1), the marginal effects without interaction effects are shown where the probability increases by roughly 3.5% when increasing the *GPA* by 10%. The marginal effects for the regional variables are quite small in magnitude. A 10% increase of each of the regional variables reduces the probability of migration by roughly 1-2%. Columns (2) - (4) show the marginal effects of the specifications with an interaction term.

Table 3. Total marginal effects for the joint probability of migration and graduating from a university [a]

	1974				**1976**			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
GPA	**0.036**	**0.061**	**0.117**	**0.069**	**0.037**	**0.055**	**0.120**	**0.066**
Parent in location	**-0.105**	**-0.105**	**-0.106**	**-0.107**	**-0.111**	**-0.112**	**-0.111**	**-0.112**
Previous migration	**0.105**	**0.105**	**0.104**	**0.103**	**0.117**	**0.116**	**0.117**	**0.116**
Highly Educated	**-0.012**	**-0.011**	**-0.011**	**0.023**	**-0.011**	**-0.010**	**-0.010**	**0.018**
Tax Base	**-0.010**	**-0.009**	**0.072**	**-0.008**	**-0.023**	**-0.023**	**0.060**	**-0.022**
Density[¤]	**-0.021**	0.004	**-0.021**	**-0.021**	**-0.019**	0.001	**-0.019**	**-0.019**
Interaction Highly Educated and GPA		**-0.035**				**-0.030**		
Interaction Tax Base and GPA			**-0.082**				**-0.084**	
Interaction Density and GPA				**-0.026**				**-0.019**

[a] Continuous variables show marginal effects by an increase of 10% over the mean. Dummy variables show the effect when changing from 0 to 1. Bold indicates significant on the 1% level.

Here, the total marginal effects of the *GPA* and the regional variables have to be calculated by adding the marginal effects of the *GPA* and the respective interaction variable. Note that this only shows the marginal effects evaluated at the means, the marginal effects changes along different points of the distribution. The marginal effects of parents residing in the original location and previous migration are higher in comparison. All else equal, the probability of migrating after graduating increases by roughly 11% if the individual has previously migrated. Having at least one parent living in the same LMA decreases the probability of migration by 10%. These marginal effects are almost constant over the different specifications. Generally, the difference in estimated effects between the two cohorts is very small, where the marginal effects tend to be slightly higher for the 1976 cohort.

Migration among the individuals at the top of the GPA distribution is of particular interest. An alternative specification was tested to examine the relationship between *GPA* and the regional variables. In this case, the *GPA* was not used as a continuous variable but instead by dummy variables indicating the individual's position in quartiles of the GPA distribution. Interaction effects with regional characteristics are tested by interaction with the dummy for individuals with a *GPA* in the top quartile.[15] The individuals belonging to this group are about 11-13 % more likely to migrate compared to the lowest quartile. When looking at the interaction effect between regional characteristics, the results consistently indicate that an individual belonging to the top 25 % of the GPA distribution is less likely to migrate compared to the other quartiles if he/she lives in a region with a high proportion of *Highly Educated*, a higher *Tax Base*, and a more densely populated labour market region.

To further illustrate the importance of regional characteristics and interaction effects, a person with the same *GPA* living in Stockholm and one living in the Umeå region are compared.[16] Both regions are characterized by a positive population growth and net in-migration. However, all three variables measuring regional characteristics indicate higher values for Stockholm. Depending on different specifications, the probability of migrating is 0.5-0.9% lower for the person living in Stockholm. The effects are generally stronger when looking at the top GPA quartile. Comparing individuals in the top 25% of GPA, the difference in probability of migrating is 1.2% lower among those living in Stockholm compared to those living in Umeå. This coincides with the findings presented above, that university graduates belonging to the top quartile of the GPA distribution already living in more prosperous regions are even more inclined to stay compared to those with a GPA in the lower quartiles. This reflects the trend of individuals that in-migrate to university regions and later migrates onwards to regions with a

[15] The results of these specifications can be found in appendix table A2.

[16] These calculations are not presented here, but available upon request.

higher tax base and population density, which seems to be stronger for individuals in the top GPA quartile. Similarly, individuals in the top GPA quartile already living in the urban regions could be more successful of finding jobs within that region, and hence stay. In order to investigate this further, the next section will present descriptive statistics of the migration pattern of the individuals by GPA quartiles.

5.1 Destinations of migrants

The results presented above show a clear tendency of systematic regional sorting on GPA indicated by patterns of out-migration. This section will present some descriptive statistics to where the individuals tend to migrate. Table 4 gives the change of the regional variables between the original location and the destination location chosen by the migrants. The average change of the regional variables between these years is included as a reference. There is a clear pattern that the migrants choose destinations characterized by, on average, higher tax bases, population density, and a larger proportion of population with a university degree. This change is larger compared to the change of the regional variables between these years.

Table 4. The average change of the regional variables for destinations chosen by the migrants

Variable[a]	**Change for migrants cohort 1974**	**Average Change between 1999 & 2004**	**Change for migrants cohort 1976**	**Average Change between 2001 & 2006**
Tax Base	35.2	27.8	32.9	29.2
Share of Highly educated	4.2	2.6	3.0	2.7
Density	93.2	3.7	75.9	4.0

[a] Tax Base are in thousands SEK per capita. Share of highly educated reflects change in percentage points. Density is in thousands persons per square meter.

This pattern is stronger for the older cohort. Individuals with a higher GPA are both more likely to migrate and consequently the migrants are more likely to choose destinations with a higher density, per capita tax base, and share of highly educated. This provides additional evidence of clustering of human capital in form of latent ability within the group of individuals with post-secondary education.

Table 5.1. Change in the distribution of GPA by type of region for cohort 1974

Region[a]	GPA Quartile 1	GPA Quartile 2	GPA Quartile 3	GPA Quartile 4
Urban centres	-3,4	-0,1	1,1	1,8
University towns	3,7	0,5	-1,1	-3,0
Other cities/towns	-0,3	-0,7	-0,1	1,0
Rural areas	0	0,1	-0,1	0,2

[a] For definitions see appendix table A2.

Table 5.2. Change in the distribution of GPA by type of region for cohort 1976

Region[a]	GPA Quartile 1	GPA Quartile 2	GPA Quartile 3	GPA Quartile 4
Urban centres	-2,1	-0,1	1,1	0,6
University towns	2,9	0,9	-0,7	-3,1
Other cities/towns	-1,0	-1,0	-0,3	0,6
Rural areas	0	0,1	-0,1	0,1

[a] For definitions see appendix table A2.

Tables 5.1 and 5.2 show the change in the distribution of GPA in four different types of regions in Sweden.[17] The change is measured as the increased percentage share of individuals in a region belonging to a specific GPA quartile. The change is measured between the years when the individuals are 25 and 30. The labour market regions are collapsed into four different types: urban centres, university towns, other cities/towns, and rural areas.[18] Definitions and locations of the regions and are given in Appendix table A3 and figure A1 respectively. Clearly, the urban centres had an increased share of individuals in the top half of the GPA distribution. This phenomenon is slightly larger for the older cohort. The two regions named "other cities" and "rural areas" also had an increase for the top 25%, while for the latter region, the increase is very small. This may reflect return migration of the graduates, which could be interesting to study further. It is also notable that there is a decrease in the share of the bottom half of the GPA in the urban region, while it is positive for university towns and rural areas. The university towns (outside urban centres) seem to lose many of their top students either to urban areas or other towns. Note that this shows the change in GPA distribution between ages 25 and 30 where a

[17] This sample only includes university students. However this group is the one with the highest GPA in the country and also the most mobile group, so it should reflect the trend of GPA flows.

[18] A similar division of region types can be found in e.g. Jauhiainen (2008). Bjerke (2012) uses a division of growth and declining regions, where the growth regions coincides to a large extent with the LMA: s that has a University or College.

selection of individuals into university towns with high GPA has already taken place before age 25. This result of higher out-migration of graduates from university towns outside the urban areas is consistent with the findings of Haapanen and Tervo (2012). The university towns are also continuously receiving new individuals with the highest grades. At the starting year, about 32% of the individuals living in university towns are in the top quartile distribution of the GPA. In absolute terms, the urban areas and the university towns have the largest share of the top students. Furthermore, other cities and rural areas have a relatively high share of individuals in the two bottom quartiles.

5.2 Robustness checks

The following robustness checks were made to test the stability and the validity of the results.

- Using the GPA from High School.
- Changing the time of observation for the two dependent variables. Migration was instead measured between ages 27 and 30 and the completion of a university degree at age 27
- Measuring migration between age 25 and 27.
- Changing the definition of migration to a change of municipality instead of labour market region.
- Lagging the regional variables up to two years.
- Estimations using samples of females and males separately.
- Excluding either the variables *Density* or *Highly Educated*.

Generally, the qualitative results from alternative specifications and sub-samples do not change for the main variables of interest, namely the GPA and the regional variables. The estimated effects of these variables still show the same signs and significance.[19] Although small differences in magnitude could be found between the alternative specifications, the conclusions drawn from the results presented in this paper would not change. For example, the parameter estimate of ρ for males was significantly higher, while the marginal effects of the GPA were the same for both genders. Estimations allowing two more years before measuring the completion of a university degree provide a higher estimate of ρ. The same result was found when only measuring migration between age 25 and 27. A higher estimate of ρ would mean that there are stronger correlated unobserved factors between the two outcomes. Lagging the regional variables by two years did not change the results. The last robustness check was done because the data showed a correlation of 0.8 between the variables *Density* and *Highly Educated.* The high correlation could be a source to the variables changing signs from negative to positive when

[19] Estimation results for the alternative specification are available upon request.

estimating the model with an interaction term between the regional characteristics and the GPA.[20] Excluding either *Density* or *Highly Educated* still gave the same change in signs of the parameter estimates when including the interaction term. Furthermore, there was no significant change for the other variables suggesting that the high correlation of the two variables does not drive the results found here.

6 Conclusions

The probability of completing a university degree and the probability of migrating to another Labour Market Area were estimated simultaneously in a bivariate probit model. These two events were related to ability measured by the grade point average (GPA) from the last year of compulsory school. The results indicate regional clustering of human capital, not only in terms of educational attainment, but also in terms of ability measured by GPA from compulsory school. The higher the GPA, the more likely the individual is to migrate, if they do not live in regions with higher population density, higher share of highly educated individuals, and a larger tax base. Regions with these characteristics keep university graduates to a larger extent and particularly the ones with high GPA. The descriptive statistics also confirm that the urban regions attract migrants with high GPA. These results are consistent with other findings of university graduates being less likely to leave urban areas. Additionally, this study shows that it is the individuals with relatively higher GPA who are even less likely to migrate from these regions. The results also indicate a positive correlation between unobserved heterogeneity affecting the probability of finishing a degree and the probability of migration between regional labour markets. Previous migration and the family ties to the region are also of great importance. Having at least one parent in the same LMA also appear to have a strong negative effect on the probability of migration. The results are robust when changing the specifications and hold their own for both females and males splitting the sample by gender.

The heterogeneity in ability is an important factor behind regional differences in human capital. Descriptive statistics on the location chosen show a tendency for choosing an urban region, especially among individuals within the top quartile of the GPA distribution. The destination chosen by the migrants were on average locations with larger tax bases, higher share of highly educated individuals, and more densely populated areas. The results concerning the importance of the regional characteristics of the region of residence before migration are consistent with previous research. Additionally in this study, the regional characteristics in the region of residence combined with the GPA are also significant when making the migration

[20] Compare e.g. the parameter estimates of the Highly Educated in the Migration equation between column 1 and 2 in table 2.1.

decision. These results add to previous literature on human capital and migration in that they show that ability in form of the GPA from the ninth grade is significant for the migration decision and that latent individual characteristics increasing the probability of graduation from university are associated with higher probability of migration.

Also, the results of this paper indicate that: (i) University graduates are more likely to leave university regions outside the big cities and (ii) this trend seem to be greater for graduates with a high GPA. This suggests that there is not only a problem of keeping graduates in regions with the out localized universities, but also that the top graduates are the most difficult to keep.

The sample used here included only university entrants. To fully understand the role of latent ability and the migration decision, individuals at all education levels should be studied. The attributes of the migration destinations are only examined briefly with descriptive statistics. A more extensive study of location choice by ability would be of interest for attaining a deeper understanding of the clustering of human capital. Another interesting extension would be to study the outcomes of the migrating individuals compared to the non-movers, in relation to education attainment, heterogeneity in ability, and the starting location.

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Appendix

Table A1. Definitions of variables

Dependent variables	**Definition**
Migration	Binary variable, equal to one if changing LA-region between ages 25 and 30; zero otherwise.
Grad	Binary variable, equal to one if graduated from university by age 25; zero otherwise.
Individual attributes	**Definition**
Female	Dummy variable, equal to one if female; zero otherwise.
GPA	The average grade of the individual from the 9th grade in Swedish, English and Mathematics. Ranges from 1-5.
Unemployed	Dummy variable, equal to one if individual received unemployment benefits; zero otherwise.
Children	Dummy variable, equal to one if individual has at least one child; zero otherwise.
Foreign born	Dummy variable, equal to one if individual was born outside of Sweden; zero otherwise.
High Education father	Dummy variable, equal to one if the individual's father have at least two years post-secondary education; zero otherwise.
High Education mother	Dummy variable, equal to one if the individual's mother have at least two years post-secondary education; zero otherwise.
Enrolment Age	Dummy variables indicating the individual's age at enrolment in university studies, equal to one for the year of enrolment; zero otherwise
Previous Migration	Dummy variable, equal to one if individual changed LA-region between ages 19 and 25; zero otherwise.
Parents in Location	Dummy variable, equal to one if the individual has at least one parent living in the same LA-region; zero otherwise.
Regional attributes	**Definition**
Density	The average population density (persons/km2) of the municipalities in a location. Logged variable.
Tax base	The average tax base per capita of the municipalities in a location. Measured in thousands SEK. 10 SEK is approximately 1.1-1.2 USD at the time of measurement.
Highly educated	The proportion of the population in the LA-region having at least two years post-secondary education.

Note: Observations pertain to initial locations (at age 25), except for the variable *Enrolment Age*.

Table A2. Total marginal effects for the joint probability of migration and graduating from a university[a].

	1974			1976		
	(2)	(3)	(4)	(2)	(3)	(4)
(Ref: GPA Q1)						
GPA Q4	**0.205**	**0.188**	**0.275**	**0.206**	**0.181**	**0.303**
GPA Q3	**0.110**	**0.110**	**0.110**	**0.111**	**0.111**	**0.111**
GPA Q2	**0.070**	**0.070**	**0.070**	**0.072**	**0.072**	**0.072**
Parent in location	**-0.107**	**-0.107**	**-0.106**	**-0.112**	**-0.120**	**-0.112**
Previous migration	**0.104**	**0.104**	**0.104**	**0.117**	**0.117**	**0.117**
Highly Educated	**-0.010**	**-0,011**	**-0.011**	**-0.009**	**-0.010**	**-0.010**
Tax Base	**-0.010**	**-0.010**	**-0.006**	**-0.023**	**-0.023**	**-0.020**
Density[¤]	**-0.021**	**-0.020**	**-0.021**	**-0.019**	**-0.018**	**-0.019**
Interaction Highly Educated and GPA Q4	**-0.002**			**-0.001**		
Interaction Density and GPA Q4		**-0.001**			**-0.001**	
Interaction Tax Base and GPA Q4			**-0.003**			**-0.004**

[a] GPA divided into Quartiles, with Q4 as the highest quartile. Interaction effects calculated with regional variable and GPA Q4 Continuous variables show marginal effects by an increase by 10% over the mean and dummy variables when changing from 0 to 1. All results are significant on the 1% level.

Table A3. Definition of the regional division

Region	**Description**[a]
Urban centres	Includes the three biggest cities in Sweden; Stockholm, Gothenburg and Malmö including suburb municipalities (50).
University towns	Includes the university towns; Umeå, Luleå, Örebro, Linköping, Uppsala and Karlstad and municipalities within the respective labour market area (46).
Other cities/towns	Includes municipalities without a university and population between 30,000 and 120,000 (84).
Rural areas	Includes municipalities with a population below 30,000 (110).

[a] The number of municipalities belonging to each group is given in parenthesis.

Figure A1. Map of Sweden by type of region.