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Human Capital Sorting

– The 'when' and 'who' of sorting of talents to urban regions

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Human Capital Sorting

- the 'when' and 'who' of sorting of talents to urban regions

Lina Ahlin[*], Martin Andersson[**] and Per Thulin[***]

ABSTRACT

Sorting of high-ability workers is a main source of urban-rural disparities in economic outcomes. Less is known about when such human capital sorting occurs and who it involves. Using data on 15 cohorts of university graduates in Sweden, we demonstrate significant sorting to urban regions on high school grades and education levels of parents, i.e. two attributes typically associated with latent abilities that are valued in the labor market. A large part of this sorting occurs already in the decision of where to study, because top universities are predominantly located in urban regions. Estimates from a selection model show that even after controlling for sorting prior to labor market entry, the 'best and brightest' are still more likely to start working in urban regions, and are also more likely to remain there over long time periods. We conclude that a) urban regions are true magnets for high-ability graduates, and that b) studies of human capital sorting need to account for selection processes to and from universities, because neglecting mobility prior to labor market entry is likely to to lead to underestimation of the extent of sorting to urban regions.

Keywords: human capital, university graduates, spatial sorting, migration, labor mobility, ability, geography of talent, spatial selection
JEL-codes: R12, J24, J61, I23

[*]CIRCLE (Centre for Innovation, Research and Competence in the Learning Economy) and Department of Economics, Lund University. e-mail: lina.ahlin@circle.lu.se. Address: CIRCLE, P.O Box 117, S-22100 Lund, Sweden.
[**]Department of Industrial Economics, Blekinge Institute of Technology (BTH), Karlskrona, and CIRCLE, Lund University. e-mail: martin.andersson@bth.se. Address:BTH, SE-371 79 Karlskrona, Sweden.
[***]Department of Industrial Economics and Management, KTH Royal Institute of Technology, Stockholm and Swedish Entrepreneurship Forum, Stockholm. E-mail: per.thulin@indek.kth.se, Address: Lindstedtsvägen 30, S-10044, Stockholm, Sweden.

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1. INTRODUCTION

Referring to London's attractiveness as place of residence for the 'best blood' in England around the late 1800s, Alfred Marshall wrote: "the most enterprising, the most highly gifted, those with the highest physique and the strongest characters go there to find scope for their abilities" (Marshall 1890). What he described is essentially a process of directed sorting of workers, where high-ability workers self-select to London. Modern research on the sources of spatial wage and productivity differentials tends to confirm this picture. A large number of wage-equation analyses shows that spatial sorting of workers on unobservable skills is the single most important reason for the urban wage premium (Combes et al. 2008, Andersson et al. 2014, Larsson 2014). A typical result is that estimated differences in wages between urban and rural workers are drastically reduced once one accounts for worker heterogeneity by including worker-level fixed effects. Some authors have tried to uncover such unobservable skills. For example, Glaeser and Maré (2001) and Wheeler (2006) use OLS regressions and include aptitude test results as a proxy for ability. They find that ability to some extent explains the reduction in the wage premium when using fixed effects but does not account for all of it. Existing studies still do not go into detail about how spatial sorting processes actually work, but rather focus on the outcome of them. As such, basic characteristics of the sorting process of human capital towards urban regions are largely unexplained.[1] Understanding spatial sorting processes of individuals on ability is yet a key issue, not least since the spatial distribution of skilled and high-ability workers is a fundamental driver of the geography of long-term growth and development (Glaeser et al. 1995, Moretti 2004, Gennaioli et al. 2013).

This paper contributes with a micro-econometric analysis of the broad patterns in sorting of several cohorts of university graduates to urban regions in Sweden. Our main goal is to analyze when sorting occurs and whom it involves. In terms of 'when', we study the link between the choice of where to study and subsequent labor market entry. This is motivated by the observation that prestigious universities with high entry requirements are in many countries, not least Sweden, primarily found in or around large urban regions. Therefore, one can expect a selection process of highly able and motivated students to urban regions to occur before labor market entry. Students with better high-school grades and from stronger socio-economic backgrounds are simply more likely to pass the entry requirements and enroll at prestigious universities. This raises the question whether ability sorting to urban regions first and foremost reflects that abler individuals are more likely to move to urban regions for study and that they remain there upon graduation, rather than ability having an independent

[1]Panel estimations of wage equations with individual fixed effects (FE) are for the most part uninformative about what factors actually drive the spatial selection process as they attribute the difference from ordinary regression results to unobserved individual effects which can be any omitted factors. FE capture many different kinds of time-invariant individual attributes and they are most often only able to account for sorting among employed workers that change region during the time span of the data.

influence in the decision of where to work subsequent graduation. Moreover, if large proportions of top graduates stay in these regions, after graduation, then it follows that studies inferring sorting from rural to urban areas based on movements of workers on the labor market may underestimate the extent of sorting.

In terms of 'who', we focus on the influence that two individual traits have on the probability that a university graduate chooses to start working in an urban region: (i) high school grades and (ii) parents' education levels. Both constitute attributes that are time-invariant and unobserved in many empirical analyses of spatial sorting. When used in empirical analyses, they are often employed as indicators of individual abilities or characteristics that are valued in the labor market.[2] High-school grades are for example frequently claimed to proxy ability or ambition (cf. Grogger and Eide 1995, Miller 1998, Geiser and Santelices 2007). Stronger family background is typically claimed to be associated with more favorable environments that raise ability (Carneiro and Heckman 2003, Björklund and Kjellström 1994). In a recent study on a sample of graduates from the north of Sweden, Berck et al (2015) do find that Swedish youth with higher grades from high school are more likely to engage in university studies and to prefer locations with higher tax bases, although they do not distinguish between what types of regions they end up in.

We first document significant sorting among university graduates. Within our sample of over 130,000 graduates, those with the highest grades and from families with stronger educational backgrounds are more likely to start working in urban regions. For example, among graduates growing up outside urban regions, over 60 percent of those with the highest high school grades and with two university-educated parents started to work in urban regions subsequent graduation. The corresponding figure for graduates with low high school grades and without a parent with a university education is in the interval of 35 to 45 percent. By tracing where graduates in our sample chose to study and their residential background, we also show that there is indeed a significant selection process towards urban regions before labor market entry. In short, about 50 percent of those graduates who grew up in the more rural parts of Sweden but started their labor market career in urban regions left for the urban regions already when they decided where to study.

To better understand the characteristics and drivers of the sorting process, we estimate a Heckman selection Probit model in which the choice of work region is conditional on the prior choice of where to study. A key question in these estimations is whether we observe sorting on high school grades and family background in the decision of locating in urban regions for work, once we control for the prior choice of study. We include a number of theoretically motivated confounding factors in each stage.

[2]We also show that there is a significant correlation between these two indicators (high-school grades and parents' education) and individual fixed effects that are estimated from a standard Mincerian wage equation.

We first estimate a model for the decision of where to study, from which we compute a selectivity adjustment term for each sub-group. We then estimate a probability model for locating in an urban region after graduation separately for each subgroup, while controlling for selectivity. To properly identify the first-stage model, we use distance to nearest university in an urban region as well as the ratio of available study places between the closest urban and rural universities as exclusion restrictions. Both these variables are directly linked to whether an individual studies in an urban region, but are less important in explaining location choice subsequent graduation.

Our results show that there is a 'brain-drain' process where university graduates with strong high school grades and better-educated parents leave the non-urban and rural areas for urban regions. Sorting of workers towards urban regions is thus not only about individuals with longer education being more likely to choose urban regions as their residence. Within the group of university educated, those with stronger ability and ambition indicators show a higher preference for urban regions. We also show that even after controlling for the initial sorting to urban regions for study, we find a significant influence of high school grades and educational background of parents on the probability to remain in urban regions for work. For instance, our estimates imply that, among university graduates that grew up in the rural parts of Sweden, 10 percent higher average high school grades increase the probability of studying in urban regions with over 5 percentage points. Still, for graduates from rural areas that studied in urban regions, those with 10 percent higher grades are 1.2 percentage points more likely to remain in urban regions for work subsequent graduation. The overall pattern of the sorting process is thus that urban regions indeed absorb the 'best and brightest'. We also show that this does not only manifest in terms of who is the most likely to start working in urban regions subsequent graduation, but also in terms of who stays in urban regions over extended periods of time.

One implication of our findings is that studies of sorting based on movements of people in the labor market may understate sorting to urban regions, because such analyses risk not capturing the significant sorting occurring before labor market entry. The results also point to that the initial flows of graduates to universities are pre-determined by the historical geography of top universities and education institutions that are often located in urban regions.

The rest of the paper is organized as follows: In section 2 we discuss the relevant literature. Section 3 presents the data and our variables. Section 4 presents a descriptive account of the flows of graduates to and from university and the geography of the university system in Sweden. The empirical strategy and the results are presented in Section 5 and section 6 concludes.

2. UNDERSTANDING SPATIAL SORTING

A large body of literature has considered spatial sorting of individuals into higher education as well as post-graduation and how these decisions correlate with individual characteristics and regional economic outcomes (cf. McHugh and Morgan 1984, Belfield and Morris 1999, Kodrzycki 2001, Groen 2004, Faggian and McCann 2006, Faggian and McCann 2009, Venhorst et al. 2010, 2011). The latter is also related to the literature on spatial sorting or agglomeration theory, as graduate migration is often directed towards larger labor markets (Ahlin et al 2014, Venhorst et al 2010, 2011) and/or more innovative regions (Faggian and McCann 2009). Nevertheless, only a few studies are concerned with how the decision of where to study in turn influences the decision of where to start working, which suggests that the latter migration decision may be endogenous (Audas and Dolton 1998, Dotti et al 2010).

Sorting into universities

There is an abundance of studies that investigate the decision of where to study, both in terms of geography, but also in terms of at what type of institution to attend. These studies typically include both individual characteristics that affect this choice, but also characteristics of the institution or the region. One common factor often found to affect this choice is the distance to higher education institutions. Both Frenette (2005, for Canada) and Spiess and Worhlich (2010, for Germany) find that distance from home to university affects both the participation decision and the decision of which institution to study at. Frenette (2005), who studies a country with large distances between provinces, finds that large distances serve as deterrents to entering university and that this effect of distance is magnified for individuals lacking study traditions in their family. Gibbons and Vignoles (2012) study the effect of distance for England. Their results suggest that distance does matter, but only for what type of institution to attend and not for the participation decision. Students living close to an institution offering the type of education they are interested in and that they have the grades to attend are more likely to choose that institution. Other studies suggest that the decision is also intertwined with the economic conditions in the state or region where the higher education institution is located (McHugh and Morgan 1984, Kodrzycki 2001, Dotti et al 2010), especially in comparison to the state or region of origin.

Sorting from university

The literature on graduate migration has been burgeoning during the past years, so much that Herbst and Rok (2013) provide an extensive survey of individual, regional and university characteristics that affect the propensity for a graduate to migrate after completed university studies.

Several characteristics of individuals are found to affect the decision to migrate post-graduation, these include gender (i.e. being female) (Faggian et al 2007, Jewell and Faggian 2013), fields of study (Jewell and Faggian 2013, Venhorst et al. 2010, Bound et al. 2004, Gottlieb and Joseph 2006), age (Gottlieb and Joseph 2006) and different measures of ability (Venhorst et al 2010, 2011). Contrary to expectations from economic theory, Faggian et al 2007 find that women are more likely to migrate after graduation than men. In line with economic theory, Gottlieb and Joseph found that older graduates are less likely to leave urban areas where they received their last degree than younger graduates.[3]

It is often found that graduates tend to leave regions that are doing less well and move towards those regions that do better (Venhorst et al 2011, Faggian et al 2009, Haapanen and Tervo 2011). Venhorst et al. (2010, 2011) study the post-migration patterns across NUTS2 regions of recent college and university graduates in the Netherlands. Their main findings suggest that the retention rate of recent graduates differ between regions at an increasing pace over time, and that a large labor market appears to be a primary determinant for this difference in retention rates. Furthermore, they find that although college and university graduates typically have similar migratory patterns across space, the migration rate of college graduates is nearly 50 percent lower than that of university graduates. Hence, what type of higher education institution students graduate from appears to have an effect on the propensity to migrate. In addition, different factors affect the location decision for college and university graduates. Whereas high costs of living play a role for college graduates, regional economic growth and unemployment affect university graduates' decision to migrate to a larger extent. However, it is also clear that many Dutch graduates work quite close to the region where they attended higher education. For the UK, Faggian and McCann (2006, 2009) also find that some regions are more likely to retain graduates than others, and that it is generally linked to favorable labor market characteristics and regional innovative performance. Some regions are also attractor regions in that they attract a disproportionate amount of graduates compared to how many that they educate. Krabel and Flöther (2012) look at the determinants for mobility of German university graduates, and finds that one of the factors that matter the most is the regional characteristics of the university region. Ritsilä and Haapanen (2003) find that highly educated are more prone to migrate towards urban areas in Finland since these generally provide larger labor markets.

Spatial sorting vs agglomeration theory

As evidenced above, graduates tend to move to urban areas post-graduation. But why? A large literature on the urban wage premium suggests that this is due to the higher wages in urban areas

[3] For a more extensive review of individual characteristics and directionality, see Herbst and Rok (2013).

(Glaeser and Maré 2001, Yankow 2006, Wheeler 2006). But whether this is due to sorting or to agglomeration economies is not clear.

Combes et al (2008) suggest that a large part of the differences in wages between different types of regions is due to individual skills, so that highly able workers tend to self-select, or sort, into certain types of regions. This is partly corroborated by Glaeser and Maré (2001), who suggest that if more able individuals self-select into cities, then the urban wage premium should be virtually zero when accounting for worker fixed effects identified for individuals that move between metropolitan areas. They furthermore find that only one-third of the wage premium can be accounted for by unobserved ability when using fixed effects and that aptitude tests (i.e. observable ability) can only to a small extent explain the urban wage premium. Yankow uses fixed effects and finds that two-thirds of the urban wage premium accrues from higher ability workers being attracted to cities. In addition, Wheeler (2006, p. 170) states "the association between wage growth and local market scale does not seem to be driven by the selection of more innately capable workers […] into cities".

De la Roca et al (2014) theoretically model and empirically test whether ability can explain sorting into urban regions. Using an overlapping generations-model with two periods, they show that individuals base their initial location decision across region-types on self-assessed ability to a large extent, and that when their true ability is revealed at the end of the first period, not all individuals find it worthwhile to migrate to the region-type where their ability would be rewarded the highest. This is predominantly found to occur among individuals with lower revealed ability than initially assumed, suggesting that these individuals are less likely to leave urban regions. Extending the reasoning to this paper, this would imply that those individuals that enter university in an urban region (where most of the top-ranked universities are located) and do not do very well might still not leave and go to a region where their skills would be rewarded higher. The opposite reasoning occurs for those that enter university in non-urban regions.

Hence, the conclusion we can draw from the previous literature is that graduates tend to move to regions with better labor market outcomes, irrespective of whether this is for university studies or for work. However, in order to properly assess which factors affect the decision to start working in a region and how large the impact of these variables are, we need to consider that individuals may be positively or negatively selected on unobservable characteristics and that selection may have already occurred with the decision where to study.

3. DATA AND VARIABLES

3.1 Data

We use university data taken from Universitetskanslerämbetet (UKÄ) covering all graduates in engineering, the social and natural sciences between 1995 and 2009 and who are at least 22 years old at the time of graduation.[4] Since some graduates may have several academic degrees, we choose to use only the latest one, as we are interested in the transition from university to work. We supplement this with data from the LISA databases that includes information on individual characteristics such as age and gender, but also locational information at different points of time. We also add information on parents' educational levels and on high school grades from other databases at Statistics Sweden. This leaves us with a total sample of 130 084 graduates.

3.2 Variables and summary statistics

As our main goal is to analyze the 'when' and 'who' of sorting to urban regions, we restrict our analysis to consider basic characteristics of graduates in our sample. First, we include indicators of family status in terms of dummy variables indicating whether a graduate is married. Prior research shows that married couples are less willing to change locations due to the colocation problem facing both spouses (Mincer 1978). Second, we include other individual background characteristics (age, gender, immigrant background) since those graduates who are older are less inclined to change locations (Gottlieb and Joseph 2006) whereas women are overall more migratory than men and minority ethnicities are less migratory (Faggian et al 2007).

The two individual characteristics of main interest are high-school grades and education levels of parents, i.e. our proxies for ability and ambition. It is of course difficult to develop good measures of such constructs, but both grades and education level of parents have been used in previous literature (cf. Grogger and Eide 1995, Miller 1998, Geiser and Santelices 2007, Carneiro and Heckman 2003, Björklund and Kjellström 1994). In the literature on the returns to education, for example, high-school grades and parents with longer education are often used as proxies of latent ability (see e.g. Eliasson 2006). Some studies also analyze the correspondence between family background and subsequent earnings and educational attainments (cf. Dustmann 2004), whereas others focus on the influence of family background on directly measurable ability indicators such as IQ (Björklund et al 2007, 2010).

High school grades are measured according to the scale 0-20 which was introduced in Sweden in 1994. For those who finished high school prior to 1994 we used a conversion table provided by

[4] To be in the dataset, the graduates have to have applied for and been granted either a Bachelor or a Master degree.

Antagning.se to convert the old grading system (1-5) to the new one. The education level of parents is identified from whether any or both of the parents have completed a university degree. To verify that our two measures of ability/ambition indeed capture some sort of individual characteristics that are valued on the labor market, we estimated a standard Mincerian wage equation with individual fixed effects (FE) and then saved the FE. We then ran a regression in which the FE of each individual was 'explained' by high school grade and a dummy that takes the value one if at least one parent has a university degree. This showed that there is a statistically significant association between individual FE from a standard Mincerian wage estimation and high school grades and the education level of parents, respectively. These results speak in favor of the argument that both indicators capture some individual trait or attribute that is valued on the labor market.[5]

We distinguish between three different types of regions. *Urban regions* are defined as the Stockholm, Gothenburg and Malmö labor market regions, and *non-urban regions* are defined as all other regions. *Rural regions* are all regions classified as countryside according to a standard categorization of municipalities developed by the Swedish Board of Agriculture.[6] No rural region host any university or institution of higher education.

Table 1 presents basic sample characteristics of the 130,084 graduates in the analysis. It also presents descriptive statistics for the two variables we will use as exclusion restrictions in the Heckman Probit model (see Section 5). About 54 percent are men and 25 percent are married. About a third of the graduates have at least one parent with a university degree and for about a fifth both parents have a university degree. Only 6 percent are either first- or second-generation immigrants. About one third of the graduates grew up in urban regions, i.e. they have an urban region as home region, and a roughly equal share grew up in rural areas. Social science and engineering constitute the largest subjects of study of the graduates in our sample, accounting for 88 percent of the graduates. Only 12 percent studied the natural sciences.

[5] The Mincerian wage equation was estimated for workers with a university degree (same as in our sample) and the controls included years of education, experience and squared experience as well as a full set of industry and occupation dummies. The model was a panel model with individual fixed effects. In the regression where the individual FE was 'explained' by the log of high school grades the coefficient was .15 with a *t*-value of 17.6. When the FE was 'explained' by a dummy for whether at least one parent has a university degree the coefficient was .05 and the *t*-value was 1.74. All these results are available from the authors upon request.

[6] Several different criteria are used to categorize municipalities, including in- and out-commuting as a fraction of total employment, percent of populated surface and distance to large city (Swedish Agricultural Board, Report 2009:2).

Table 1. Sample characteristics

Variable	Mean	Std. dev.	Min	Max
Male	0.54	0.50	0	1
Age	29.72	3.42	22.00	42.00
Average high school grade	16.00	2.28	3.05	20.00
Married	0.25	0.43	0	1
Parents' and partner's education				
Highly educated father	0.32	0.46	0	1
Highly educated mother	0.27	0.44	0	1
At least one highly educated parent	0.32	0.46	0	1
Two highly educated parents	0.17	0.38	0	1
Highly educated partner	0.20	0.40	0	1
Foreign background				
First-generation immigrant	0.03	0.18	0	1
Second-generation immigrant	0.03	0.18	0	1
Home region				
Urban home region	0.33	0.47	0	1
Non-urban home region	0.67	0.46	0	1
Rural home region	0.31	0.48	0	1
Field of education				
Social sciences	0.45	0.50	0	1
Natural sciences	0.12	0.33	0	1
Engineering	0.43	0.50	0	1
Time distance to closest urban university	97.3	123.8	5.75	737.6
Ratio of closest urban to rural university study places	3.37	3.43	0.003	535.9

Note: the descriptive statistics are based on data on 130,084 graduates graduating from universities in Sweden 1995-2009 and are at ages 22-29 in the graduation year.

4. SPATIAL SORTING TO URBAN REGIONS FOR STUDY AND WORK

What are the broad patterns in sorting of university graduate towards urban regions? Figure 1 shows, by high school grades and parents' education, the percentage of all graduates who grew up and went to high school outside the urban regions but started their professional labor market career in urban regions.

It is clear that those graduates with higher grades and better-educated parents systematically show stronger inclination to choose to start their labor market career in urban regions. For instance, among graduates from non-urban regions with top grades, over 60 % percent start their labor market career in urban regions. The corresponding figure for graduates from the same origin but with lower grades is about 38 percent. Likewise, about 44 percent of graduates with no university educated parent locate in urban regions subsequent graduation, whereas over 60 percent do so among those where both parents have a university education. This shows that sorting of workers towards urban regions is not restricted to that people with longer education prefer urban regions; even within the group of university educated, those with better scores on ability indicators show a higher preference for urban regions.

To further probe the broad patterns of the sorting process, Table 2 shows the distribution of graduates in terms of their previous location. The first level shows where they enter the labor market subsequent graduation, the second if they studied in urban or non-urban (NON-U) regions and the third whether they have urban or non-urban regions as their "home region". On all the levels we include the percentage having a parent with higher education and the percentage with below average, average and above average grades from high school.

Just over 60 percent of the university graduates in our sample locate in areas categorized as urban. Decomposing the graduates into where they studied, it becomes clear that there is some selection occurring already with the decision where to study: 64 percent of those entering the labor market in urban areas have studied in urban areas and 76 percent of those entering the labor market outside urban areas also studied at universities outside urban regions. Further classifying the sample into where the graduates lived prior to entering university illuminates that a significant portion of those graduates that originate from non-urban regions but start their professional working career in urban regions move to urban regions already when they enroll at universities. About 50 percent of these graduates moved to urban regions at the time they initiate their university studies. After graduation, this group is 'stayers' in urban regions. Another marked pattern is the asymmetry in the flows with regards to university studies. It is much more uncommon to leave urban home regions to study outside urban regions than it is to move from non-urban to urban regions for study.

There are also clear patterns with regard to how high school grades and parents' education relate to the different pathways illustrated in the table. The first row shows that while the difference in average grades between graduates starting to work in urban and non-urban regions are relatively minor, there are somewhat larger differences in parents' education and grades in the highest percentile. The difference here amounts to about 10 percentage points or higher. Looking at the next level, it is evident that those studying in urban regions tend to have better educated parents as well as a stronger presence in the percentile of highest grades. This is true if we compare urban and non-urban study among those ending up in urban and non-urban regions, respectively. However, if one holds study region constant and only compare groups depending on where they choose to start work it is clear that those eventually deciding to start working in urban regions are more likely to have top grades and more likely to have parents with university education. This is also true when taking their home region into account. The general picture is thus one of 'brain drain' from non-urban regions where those with the highest grades and better-educated parents leave the non-urban and rural areas for urban regions, and they do so already when entering university.

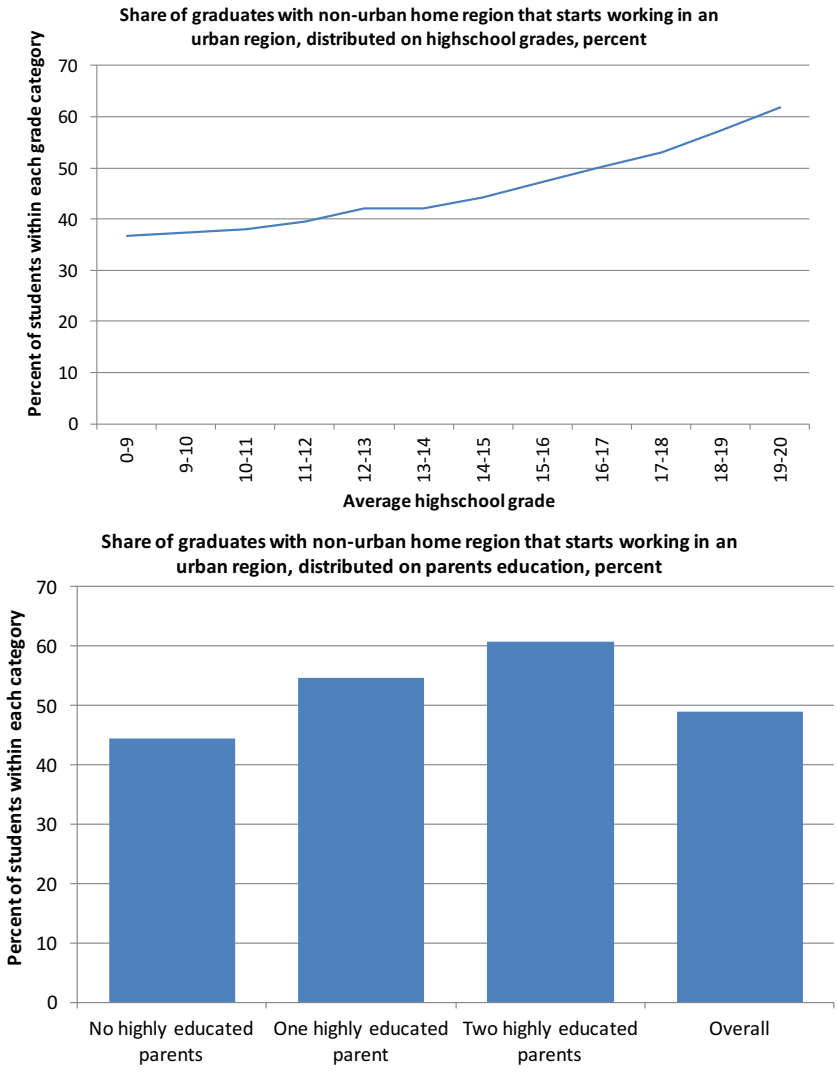

Figure 1. *Net flow of university graduates 1995–2009 in Sweden to urban regions distributed on average high school grades (upper panel) and parents' education (lower panel), percent.*

One reason why individuals with better grades and stronger family background move to urban regions to study is that most (if not all) top universities in Sweden are located in or near the urban regions. Table 3 shows the spatial distribution of universities, the average entry GPA of students, their relative rankings in Sweden as well as the percentage of return migrants (i.e. graduates who move away to study and return home after university), repeat migrants (those that move after graduation but do no return home), late migrants (those who study in the same region as they lived in when they were 16 and then move after university), non-migrants (those who remain in the same region during all three periods) and university stayers (those who move away to study and then stay where they studied after graduation) at each university in our sample.

Table 2. Distribution of graduates and individual characteristics by home, study and work location (cohort of graduates 1995–2009).

WORK:	URBAN				NON-U			
Share, %	61.9				38.1			
Number	80,552				49,532			
Average grade	16.2				15.6			
At least one highly ed. parent, %	46.5				32.2			
Two highly ed. parents; %	20.6				12.1			
Avg. grade in lowest percentile, %	0.8				1.4			
Avg. grade in middle percentile, %	51.3				62.0			
Avg. grade in highest percentile, %	47.9				36.6			
Males, %	54.6				53.1			
STUDY:	URBAN		NON-U		URBAN		NON-U	
Share, %	63.5		36.5		23.7		76.3	
Number	51,157		29,395		11,750		37,782	
Average grade	16.5		15.7		16.2		15.4	
At least one highly ed. parent, %	49.4		41.6		39.9		29.7	
Two highly ed. parents; %	22.4		17.5		16.6		10.7	
Avg. grade in lowest percentile, %	0.7		1.1		0.9		1.6	
Avg. grade in middle percentile, %	46.0		60.4		50.1		65.7	
Avg. grade in highest percentile, %	53.3		38.4		49.0		32.8	
Males, %	55.8		52.5		52.8		53.2	
HOME:	URBAN	NON-U	URBAN	NON-U	URBAN	NON-U	URBAN	NON-U
Share, %	57.5	42.5	27.6	72.4	24.0	76.0	5.6	94.4
Number	29,417	21,740	8,101	21,294	2,820	8,930	2,105	35,677
Average grade	16.5	16.5	15.7	15.7	16.6	16.1	15.7	15.4
At least one highly ed. parent, %	52.8	44.8	48.4	39.0	51.1	36.4	45.0	28.9
Two highly ed. parents; %	24.7	19.3	20.6	16.4	24.0	14.3	20.4	10.1
Avg. grade in lowest percentile, %	0.7	0.7	1.2	1.1	0.6	0.9	1.0	1.6
Avg. grade in middle percentile, %	46.1	45.9	60.5	60.4	44.3	52.0	60.4	66.0
Avg. grade in highest percentile, %	53.2	53.4	38.2	38.5	55.1	47.1	38.7	32.4
Males, %	55.5	56.2	48.5	54.0	49.5	53.8	47.5	53.6

Note: The table is based on 130,084 university graduates from 15 cohorts (1995-2009). URBAN comprises Stockholm, Göteborg and Malmö. NON-U is the rest of Sweden.

Table 3. Universities in Sweden.

University	Average GPA	Rank 2007	Rank 2013	Repeat migrants	Return migrants	University stayers	Late migrants	Non migrants	Location
Handelshögskolan i Sthlm	18.99	1	2	0.0293	0.0174	0.0294	0.5481	0.3759	Urban
Chalmers tekniska högskola	17.05	6	6	0.5360	0.3472	0.0082	0.0067	0.1018	Urban
Uppsala universitet	16.69	5	5	0.2827	0.1345	0.0346	0.1475	0.4007	Urban
Linköpings universitet	16.66	7	8	0.4649	0.1731	0.0256	0.0748	0.2616	Non-urban
Lunds universitet	16.65	4	7	0.5412	0.2045	0.0138	0.0355	0.2050	Urban
Kungl. Tekniska högskolan	16.53	9	4	0.1102	0.0516	0.0791	0.5251	0.2340	Urban
Göteborgs universitet	16.41	8	9	0.3999	0.3895	0.0125	0.0190	0.1791	Urban
Stockholms universitet	16.36	10	10	0.0512	0.0349	0.0519	0.6417	0.2203	Urban
Sveriges lantbruksuniversitet	16.03	3	3	0.5147	0.1991	0.0501	0.0872	0.1490	Urban
Karolinska institutet	15.93	2	1	0.1089	0.1411	0.0726	0.4718	0.2056	Urban
Umeå universitet	15.65	12	11	0.4108	0.2668	0.0147	0.0370	0.2707	Non-urban
Luleå tekniska universitet	15.52	13	14	0.4656	0.2753	0.0192	0.0389	0.2010	Non-urban
Högskolan i Jönköping	15.42	20	13	0.4318	0.3389	0.0118	0.0498	0.1677	Non-urban
Karlstads universitet	15.25	18	17	0.4181	0.3187	0.0103	0.0444	0.2084	Non-urban
Örebro universitet	15.08	14	12	0.3287	0.3063	0.0153	0.0703	0.2795	Non-urban
Högskolan i Borås	14.96	15	21	0.4466	0.4343	0.0070	0.0143	0.0978	Non-urban
Södertörns högskola	14.90	11	15	0.0600	0.0544	0.0384	0.5946	0.2526	Urban
Högskolan i Skövde	14.78	30	27	0.4568	0.3535	0.0201	0.0479	0.1218	Non-urban
Högskolan i Halmstad	14.78	23	22	0.5526	0.3262	0.0093	0.0200	0.0919	Non-urban
Mälardalens högskola	14.78	22	19	0.3380	0.3101	0.0263	0.0943	0.2312	Non-urban
Mittuniversitetet	14.72	27	23	0.3377	0.3385	0.0181	0.0712	0.2345	Non-urban
Malmö högskola	14.53	19	16	0.5642	0.3382	0.0101	0.0189	0.0685	Urban
Blekinge Tekniska Högskola	14.51	26	20	0.5257	0.3119	0.0212	0.0388	0.1024	Non-urban
Högskolan Kristianstad	14.43	21	28	0.5498	0.3853	0.0041	0.0050	0.0558	Non-urban
Högskolan i Gävle	14.35	29	24	0.3630	0.3030	0.0188	0.0921	0.2231	Non-urban
Högskolan Väst	14.33	24	26	0.5572	0.3894	0.0056	0.0054	0.0424	Non-urban

Note: The table reports statistics for different universities and institutions of higher education in Sweden. Rank refers to the overall ranking of the each respective university according to *Urank*, which is an independent ranking of universities in Sweden based on 27 different variables (www.urank.se). The different types of migrants are defined in the main text. Average GPA refers to the average high school grade of students enrolled at the different universities. The table excludes *Växjö University* and *Kalmar Högskola* because these two institutions merged and formed Linné University in the 2000s which means that rank and other other statistics are difficult to report in a consistent manner. Graduates from these institutions are still included in the main analysis and are included in the 130,084 graduates in the study.

The pattern that emerges is that universities with higher entry requirements and that are ranked higher in Swedish (as well as international) university rankings are predominantly located in urban regions. They also have higher shares of university stayers and non-migrants than those universities located in non-urban regions.

Non-urban universities have higher shares of return migrants than urban universities. All in all, this implies that those entering universities in urban regions are more likely to stay there, this is especially true for the universities in the Stockholm region (Handelshögskolan i Stockholm, Kungliga Tekniska Högskolan and Stockholms universitet) whereas those that enter universities in non-urban regions are likely to move back to their home region or continue moving (return and repeat migrants).

5. AN EMPIRICAL MODEL OF SORTING OF UNIVERSITY GRADUATES

5.1 Estimation strategy

We are interested in the influence that individual characteristics, in particular our two measures of latent ability and ambition, have on the probability that a recent graduate begins his/her working career in an urban region. The probability may differ depending on whether the graduate studied in an urban region or a rural region, since the distribution of graduates across these two regions is likely to be conditional on both observable and unobservable traits. The descriptive analysis indeed indicates that graduates who study in urban regions have higher grades and come from families with a stronger educational background, and are more likely to remain in urban regions subsequent graduation.

This raises at least two issues. First, the sorting of workers on observed ability indicators towards urban regions for work could in fact reflect that they influence the prior sorting process (i.e. the decision to study in urban regions) rather than an influence in the decision of where to locate subsequent graduation. Second, having studied in urban regions may raise the probability of working in urban regions after completing university studies compared to graduates from non-urban regions. Both issues can be addressed with a sample selection model. We estimate a Heckman two-step model that consists of a selection equation with two possible outcomes:

$$z_i^* = w_i\gamma + u_i$$

$$z_i = \begin{cases} 1 \; if \; z_i^* > 0 \\ 0 \; if \; z_i^* \leq 0 \end{cases}$$

and an outcome equation:

$$y_i = \begin{cases} x_i\beta + \varepsilon_i \; if \; z_i^* > 0 \\ - \qquad\quad if \; z_i^* \leq 0 \end{cases}$$

where y_i is only observed if z_i^* is greater than 0. The selection problem then occurs because the error terms in the two equations are correlated which leads to both biased and inconsistent estimates. Since we have a sample selection problem with limited dependent variables, we use the Heckman two-step model allowing for a Probit model in the outcome equation rather than an OLS model (i.e. a so-called bivariate Probit model with sample selection).

In the bivariate Probit model, we have four possible outcomes of which two are indistinguishable. In our case, this is equivalent to the outcomes "not study in urban regions, not work in urban regions" and "not study in urban regions". Hence, we can only observe the three following types of observations; (i) $y_1 = 0$, (ii) $y_1 = 1, y_2 = 0$ and (iii) $y_1 = 1, y_2 = 1$ with the following probabilities:

$$\Pr(y_1 = 0) = \Phi(-x_1\beta_1)$$

$$\Pr(y_1 = 1, y_2 = 0) = \Phi(x_1\beta_1) - \Phi_2(x_1\beta_1, \, x_2\beta_2, \rho)$$

$$\Pr(y_1 = 1, y_2 = 1) = \Phi_2(x_1\beta_1, \, x_2\beta_2, \rho)$$

where ρ is the correlation between the error terms. These can be used to generate the log-likelihood function:

$$lnL = \sum_{i=1}^{N} \{y_{i1}y_{i2} ln\Phi_2(x_1\beta_1, \, x_2\beta_2, \rho\} + \; y_{i1}\,(1 - y_{i2}) ln[\Phi(x_1\beta_1) - \Phi_2(x_1\beta_1, \, x_2\beta_2, \rho)] + (1 - y_{1i}) ln\Phi(-x_1\beta_1)$$

The first term is the probability of both studying and working in an urban region, the second term is the probability of working in an urban region without having studied there and the third term is the probability of not having studied in urban regions.

An issue in the Heckman selection model concerns exclusion restrictions, which are needed to properly identify the selection process (Puhani 2000). The model can be identified when using the same variables in the selection and the outcome equation, but the identification then only comes from distributional assumptions and not variation in the independent variables that often results in imprecise estimates (Wooldridge 2002).

In our empirical context this implies that we need variables that influence the probability of university studies in urban regions (selection equation) but not the probability of starting to work in urban regions (outcome equation). Such variables are in principle instruments. We employ two variables as exclusion restrictions: (i) distance to the closest urban university from the home region and (ii) the number of study places, i.e. the number of students allowed to be enrolled, in the closest urban university in relation to the number of study places at the closest non-urban university. As shown in the literature review, distance to university does not affect the decision to participate in higher education, but may determine at which institution to study at (cf. Gibbons and Vignoles 2012). The closer an individual lives to a university in an urban region, the larger the probability than he/she studies in an urban region, though this distance is not likely to influence the probability of working in an urban region. However, distance is not all that matters. Also the extent of study places, i.e. the number of students that universities can accommodate given the compensation from the state authorities. Even if the distance to the closest urban university may be small, there may be few study places available. In view of this, we also include the number of study places at the closest urban university in relation to the number of study places at the closest non-urban university. This variable is assumed to primarily influence the decision of where to study and not the decision where to locate subsequent graduation. A further motivation of this assumption is that the number of study places at different universities is determined by the government in their yearly budget. This allocation has in part been used as a regional policy instrument, giving regions with bad labor market prospects a larger number of study places as a compensation. Since smaller regions generally have more unemployment, this implies that study places in these areas may expand more than in urban regions, further reducing the likelihood that the variable would matter in the decision of where to locate subsequent graduation.

5.2 Results

We estimate the selection model for three groups of graduates; (i) all graduates (Table 4), (ii) graduates who grew up and went to high school outside the urban regions (Table 5), and (iii) graduates originating from rural regions (Table 6). The focus on graduates with non-urban regions is motivated by that this group represents true migrants to urban regions, and not simply that they remain in the region they grew up in. The rural group is a subset of the non-urban group and comprises of university graduates who grew up and went to high school in the countryside. There are no universities or institutions of higher education in this group of regions, which means that the individuals in this group have to move to undertake university studies. The analysis of this group will illuminate rural to urban flows of human capital and rural to urban 'brain-drain'.

The results for our full sample are shown in Table 4. We report two outcome equations and two selection equations. Both outcome equations report the estimated influence of the variables in the model on the probability of starting to work in an urban region upon graduation. The left one is for those graduates who chose to study in urban regions, and the right one for those who chose to study outside urban regions.

It is clear that the outcome and selection equations are not independent of each other, which means that a selection model is warranted. The test statistics for the Wald test of independent equations rejects the null hypothesis of independence between the outcome and selection equations, hence the decision of where to locate subsequent graduation is not independent from the prior decision of where to study.

We also find that both exclusion restrictions are statistically significant and have the expected sign. Longer distance to the closest urban university or institution of higher education reduces the probability of studying in urban region. The effect is quantitatively important. The estimate implies that a doubling of the distance to the closest university in an urban region reduces the probability of studying in an urban region with about 8.5 percentage points. If the closest urban university has many study places relative to the closest non-urban university, the probability of studying in an urban region is significantly increased.

We also find that being male, older, immigrant and married, respectively, is associated with a higher probability of studying in urban regions. Having a highly educated partner reduces the probability of studying in urban regions. Individuals that grew up and went to high school in urban regions are also more likely to study in urban regions, indicating a type of 'home bias' effect. This effect is quantitative very large. All else constant, having an urban region as home region raises the probability

of studying in an urban region with almost 18 percentage points, compared to an individual having a non-urban home region. Individuals with rural home regions also show a higher probability of studying in urban regions. One explanation for this is that rural residents need to migrate wherever they choose to study.

Table 4. The probability of start working in an urban region subsequent graduation. Marginal effects (all graduates)

Pr(working in an urban region)	**Urban study**		**Non-urban study**	
	Outcome	*Selection*	*Outcome*	*Selection*
Male	0.0200***	0.0173***	0.0156***	–0.0171***
	(0.0033)	(0.0027)	(0.0036)	(0.0027)
Age, logarithm	–0.0001	0.2105***	0.2951***	–0.2045***
	(0.0150)	(0.0122)	(0.0172)	(0.0122)
First-generation immigrant	0.0070	0.0542***	0.0478***	–0.0517***
	(0.0080)	(0.0072)	(0.0102)	(0.0072)
Second-generation immigrant	0.0262***	0.0561***	0.0201*	–0.0562***
	(0.0082)	(0.0070)	(0.0105)	(0.0070)
Average high school grade, log	0.0310**	0.4573***	0.0111	–0.4512***
	(0.0140)	(0.0087)	(0.0128)	(0.0087)
Highly educated partner	0.0143***	–0.0149***	0.0047	0.0144***
	(0.0046)	(0.0039)	(0.0050)	(0.0038)
Married	–0.0222***	0.0096***	–0.0500***	–0.0097***
	(0.0042)	(0.0036)	(0.0047)	(0.0036)
Highly educated parent	0.0265***	0.0415***	0.0527***	–0.0397***
	(0.0034)	(0.0026)	(0.0038)	(0.0026)
Natural sciences (*ref: social science*)	–0.0083*	–0.0084**	–0.0721***	0.0108***
	(0.0049)	(0.0040)	(0.0051)	(0.0040)
Engineering (*ref: social science*)	–0.0237***	0.0811***	–0.0927***	–0.0806***
	(0.0033)	(0.0028)	(0.0037)	(0.0028)
Urban home region (*ref: non-urban but not rural*)	0.1437***	0.1787***	0.1760***	–0.1696***
	(0.0118)	(0.0044)	(0.0100)	(0.0043)
Rural home region (*ref: non-urban but not rural*)	–0.0050	0.0198***	–0.0085**	–0.0213***
	(0.0036)	(0.0030)	(0.0036)	(0.0030)
Exclusion restrictions				
Time distance to closest urban university, log	–	–0.0849***	–	0.0891***
		(0.0016)		(0.0015)
Ratio of closest urban to rural university study places	–	0.0186***	–	–0.0171***
		(0.0013)		(0.0012)
Wald test of independent equations, H0: $\rho = 0$	34.4***		564.4***	
Number of observations	130,084		130,084	
Number of uncensored observations	62,907	–	67,177	–

Note: *, ** and *** denote statistical significance at the 10-, 5-, and 1-percentage level, respectively. Robust standard errors are reported within the parentheses. All regressions include dummy variables for years.

Furthermore, the results confirm that having better grades and having at least one parent who has a university degree is associated with a higher probability of studying in urban regions. Both effects are significant. The estimates imply that 10 percent higher average high school grades correspond to an increase in the probability of studying in an urban region with about 4.6 percentage points. Having at least one parent with a university degree raises the probability of studying in an urban region with about 4.2 percentage points, compared to an individual without any parent with a university degree. This confirms that individuals with better grades and from families with a stronger educational background are more likely to study in urban regions.

Turning to the outcome equations, we start with the probability of starting to work in an urban region among those who studied in urban regions, i.e. the left outcome equation. We find that graduates with better grades as well as with at least one parent with a university degree are more likely to start working in an urban region, even after controlling for the prior selection process into urban study locations. In quantitative terms, the influence of these individual characteristics is still lower in the second-stage decision of where to start working compared to the first-stage decision of studying in urban regions. For example, our estimates here imply that 10 percent higher average high school grades is associated with a rise in the probability of starting to work in an urban region with about 0.3 percentage points, i.e. a more than tenfold lower effect than high school grades have in the decision of studying in urban regions.[7]

For those graduates that studied outside urban regions, average high-school grades have no statistically significant influence, even though the estimated parameter is positive. There is thus no sorting on grades towards urban regions in the location decision among those who did not study in urban regions. We see two potential explanations for this result. One is that grades reflect both ability and ambition among those with good enough grades to enter 'better' universities in urban regions. Because of this, grades for this group also reflects ambition for a labor market career and are therefore more likely to move to the labor market opportunities provided in urban regions. Another potential explanation is that having good grades and studying in urban regions pick up a university effect. Good grades and urban study is likely to reflect graduation from prestigious and well-known universities (see Table 3). If employers put value at which universities their (potential) employees have studied (a signaling effect), then the effect of grades for those that graduate from universities in urban regions could capture such a university effect which may work as an entry ticket to good employers in urban regions.

[7] One explanation for this rather large divergence in the estimated effect of grades between the outcome and selection equation could be due to that the sample in this case comprise all graduates, of which some may show no migration at all. As will be seen in Tables 5 and 6, the difference in the marginal effect between the selection and outcome equation is reduced when focusing on graduates with non-urban regions as home regions.

We still find, however, that also for the group of graduates that studied outside urban regions, having at least one highly educated parent raises the probability of migrating to an urban region for work subsequent graduation. Although high school grades have no effect, family background matters in the choice of migrating to urban regions subsequent graduation, reflecting a sorting on an individual trait with a bearing on ability.

As for the control variables in the outcome equation, we find that university graduates with a highly educated partner are more likely to start working in urban regions if they studied there. This is consistent with the argument that these graduates need to solve the dual labor market career problem, which is facilitated by a location in large regions with a diversified labor market (cf. Costa and Kahn 2000). Males are consistently more likely to start working in urban regions and married graduates significantly less likely. Among graduates studying in urban regions, older graduates are not more likely to start working in urban regions, although those who studied outside urban regions are. It appears that the age-effect is picked-up in the decision of where to study. We also observe some differences between fields of education, where graduates studying social sciences appear to be more likely to move to urban regions subsequent graduation.

Table 5 reports results for graduates that all have non-urban regions as home regions. The graduates in this group that end up in urban regions following graduation indeed migrate to urban regions. In broad terms, the results for this set of graduates show similar patterns as in Table 4. First, the exclusion restrictions have the same sign as before and are of similar magnitude in terms of their marginal effects. Second, these results again confirm that individuals with better grades and from families with stronger educational backgrounds are more likely to choose to study in urban regions, all else equal. The magnitude of order of the influence of both variables in the selection equation for studying in urban regions is larger than those for all graduates in Table 4. This is expected since studying in urban regions for this group of graduates entails migration to urban regions. These results again confirm that the flow of individuals from non-urban to urban regions for university studies is far from random. Instead, it involves university students with strong scores on our indicators for ability and ambition.

Table 5. The probability of start working in an urban region subsequent graduation. Marginal effects (Graduates with non-urban regions as home regions)

Pr(working in an urban region)	**Urban study**		**Non-urban study**	
	Outcome	*Selection*	*Outcome*	*Selection*
Male	0.0246***	0.0052	0.0157***	–0.0044
	(0.0052)	(0.0034)	(0.0035)	(0.0034)
Age, logarithm	0.0454*	0.2323***	0.2716***	–0.2263***
	(0.0258)	(0.0152)	(0.0166)	(0.0150)
First-generation immigrant	0.0279*	0.0524***	0.0421***	–0.0490***
	(0.0149)	(0.0099)	(0.0104)	(0.0099)
Second-generation immigrant	0.0045	0.0289***	0.0088	–0.0271**
	(0.0160)	(0.0107)	(0.0112)	(0.0107)
Average high school grade, log	0.1437***	0.4897***	0.0154	–0.4866***
	(0.0253)	(0.0112)	(0.0122)	(0.0111)
Highly educated partner	0.0257***	–0.0084*	0.0048	0.0072
	(0.0076)	(0.0048)	(0.0048)	(0.0047)
Married	–0.0453***	0.0028	–0.0429***	–0.0028
	(0.0072)	(0.0045)	(0.0045)	(0.0044)
Highly educated parent	0.0531***	0.0589***	0.0457***	–0.0576***
	(0.0059)	(0.0033)	(0.0037)	(0.0033)
Natural sciences (*ref: social science*)	0.0027	–0.0185***	–0.0541***	0.0207***
	(0.0082)	(0.0051)	(0.0050)	(0.0051)
Engineering (*ref: social science*)	–0.0265***	0.0774***	–0.0775***	–0.0774***
	(0.0055)	(0.0035)	(0.0037)	(0.0035)
Rural home region (*ref: non-urban*)	–0.0048	0.0213***	–0.0059*	–0.0233***
	(0.0048)	(0.0031)	(0.0032)	(0.0031)
Exclusion restrictions				
Time distance to closest urban university, log	–	–0.0901***	–	0.0932***
		(0.0018)		(0.0017)
Ratio of closest urban to rural university study places, log	–	0.0231***	–	–0.0204***
		(0.0015)		(0.0015)
Wald test of independent equations, H0: $\rho = 0$	11.9***		518.4***	
Number of observations	87,641		87,641	
Number of uncensored observations	30,670	–	56,971	–

Note: *, ** and *** denote statistical significance at the 10-, 5-, and 1-percentage level, respectively. Robust standard errors are reported within the parentheses. All regressions include dummy variables for years.

The estimated influence of the controls is roughly similar to Table 4. One notable difference is that we do not find any differences between males and females in the decision to leave non-urban regions for university studies in urban regions. However, men are significantly more likely to start working in urban regions irrespective of whether they studied in urban or non-urban regions. We also do not find that having an educated partner and being married have any statistically significant effect at the 5-percentage level.

Looking at the outcome equations, we see similar results as in Table 4. For university graduates who left non-urban regions for university studies in urban regions, we see that those with a degree from an urban university are more likely to start working in an urban region if they have higher grades and at least one parent with a university degree. The estimated marginal effects for grades implies that a university graduate who studied in urban regions and has 10 percent higher average high school grades compared to a similar graduate is 1.4 percentage points more likely to remain in urban regions for work. Conversely, having at least one parent with a university degree raises the probability that a graduate remains in an urban region for work with 5.3 percentage points.

Comparing the results of the outcome equation for those that did study in urban regions with those that did not shows similar differences as in Table 4. Grades do not have any statistically significant influence in the outcome equation for the latter group whereas the dummy for whether a graduate has at least one highly educated parent does. This is the same pattern as in Table 4, and can be explained in a similar way.

Table 6 presents similar results for graduates that originate from rural regions, i.e. the Swedish countryside. This is a group of graduates who grew up and went to high school in regions where there are no local universities or institutions of higher education. The overall patterns observed in the results reported in Tables 4 and 5 holds for this group as well. It is clear that individuals with better grades and at least one parent with a university degree are more likely to study in urban regions. The estimated marginal effects of these variables in the probability of studying in urban regions are in fact highest for this group. Having 10 percent better grades increases the probability of studying in urban regions with over 5 percentage points. Likewise, having at least one university-educated parent raises the probability of urban study with over 7 percentage points.

Even after controlling for the prior selection, we see that graduates with better grades and from families with stronger educational tradition are more likely to start their labor market careers in urban regions. Again, the estimated marginal effects are quantitatively important. Among graduates from rural areas that studied in urban regions, those with 10 percent higher grades are 1.2 percentage points more likely to remain in urban regions for work subsequent graduation. Those with at least one parent having a university degree are about 4.4 percentage points more likely to be 'urban stayers' subsequent graduation. As before, we find no differences between men and women with regards to their inclination to study in urban regions, although men are significantly more likely to start working in urban regions. Older graduates are also more likely to start working in urban regions, whereas married graduates are less likely to do so.

Table 6. The probability of start working in an urban region subsequent graduation. Marginal effects (Graduates with rural regions as home regions)

Pr(working in an urban region)	**Urban study**		**Non-urban study**	
	Outcome	*Selection*	*Outcome*	*Selection*
Male	0.0377***	0.0016	0.0153***	–0.0008
	(0.0079)	(0.0049)	(0.0050)	(0.0049)
Age, logarithm	0.0953**	0.2599***	0.3078***	–0.2508***
	(0.0392)	(0.0222)	(0.0245)	(0.0219)
First-generation immigrant	0.0474*	0.0658***	0.0234	–0.0625***
	(0.0249)	(0.0158)	(0.0163)	(0.0158)
Second-generation immigrant	0.0195	0.0171	–0.0086	–0.0153
	(0.0267)	(0.0167)	(0.0172)	(0.0166)
Average high school grade, log	0.1195***	0.5205***	–0.0010	–0.5185***
	(0.0329)	(0.0162)	(0.0173)	(0.0162)
Highly educated partner	0.0161	–0.0116*	0.0039	0.0096
	(0.0116)	(0.0070)	(0.0069)	(0.0068)
Married	–0.0463***	0.0057	–0.0504***	–0.0057
	(0.0108)	(0.0066)	(0.0065)	(0.0064)
Highly educated parent	0.0438***	0.0716***	0.0377***	–0.0703***
	(0.0083)	(0.0048)	(0.0054)	(0.0048)
Natural sciences (*ref: social science*)	–0.0071	–0.0098	–0.0556***	0.0104
	(0.0121)	(0.0073)	(0.0072)	(0.0072)
Engineering (*ref: social science*)	–0.0362***	0.0728***	–0.0759***	–0.0734***
	(0.0082)	(0.0051)	(0.0053)	(0.0051)
Exclusion restrictions				
Time distance to closest urban university, log	–	–0.1436***	–	0.1472***
		(0.0029)		(0.0027)
Ratio of closest urban to rural university study places, log	–	0.0257***	–	–0.0212***
		(0.0025)		(0.0024)
Wald test of independent equations, H0: $\rho = 0$	7.8***		230.0***	
Number of observations	40,629		40,629	
Number of uncensored observations	14,150	–	26,479	–

Note: *, ** and *** denote statistical significance at the 10-, 5-, and 1-percentage level, respectively. Robust standard errors are reported within the parentheses. All regressions include dummy variables for years.

In summary, our results show that there is a 'brain-drain' process where university graduates with strong high school grades and better-educated parents leave the non-urban and rural areas for urban regions. Even after controlling for the first-stage sorting to urban regions for study, we find a significant influence on our basic ability indicators on the probability to remain in urban regions for work. The overall pattern of the sorting process is that the 'best and brightest' leave for urban regions already in the decision where to study, and are also more likely to stay in such regions after graduation. One implication of this is that studies of sorting based on movements of people in the

labor market may understate sorting to urban regions, because such analyses risk not capturing the significant sorting occurring before labor market entry.

5.3 The empirical relevance of the first location after graduation – the longevity of an urban location

The previous analyses focused on the first location choice of university graduates directly after graduation. The extent to which this choice of location is representative for the spatial allocation of human capital naturally depends on its duration. For example, if university graduates that originate from non-urban regions and who choose to start working in urban regions after graduation only remain in those regions a few years and then move back to non-urban regions, then an analysis of this first location choice is less relevant.

To probe the Heckman Probit analyses, Figure 2 illustrates how long university graduates that locate in urban regions subsequent graduation remain in such regions. Since we have different cohorts (1995-2009) we present the longevity of the first location choice as Kaplan-Meier survival estimates. The rationale for this is naturally that different cohorts have different length of exposure in our data. Since our first cohort is observed in year 1995, the maximum number of years that we can follow the location choice is 15 years.

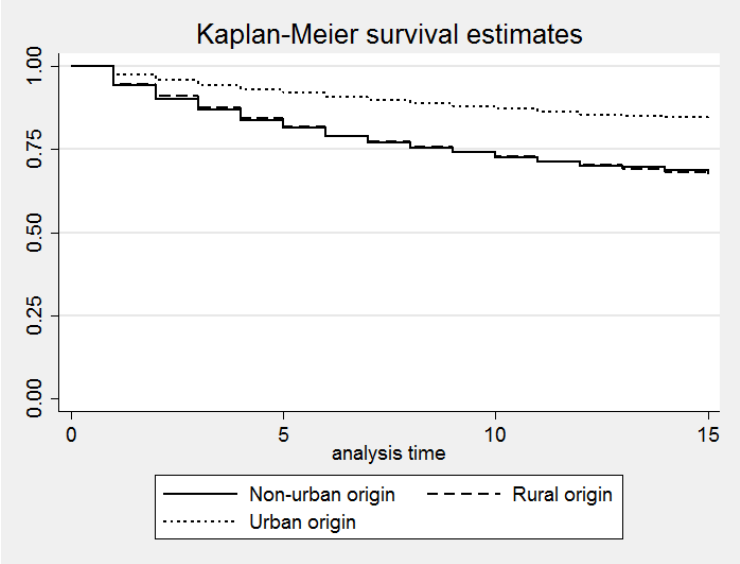

***Figure 2**. Longevity in the choice of locating in urban regions subsequent graduation, university graduates in Sweden 1995-2009*

It is clear from the figure that the first choice of the type of region to live and work in is rather durable over time. Well over 75 percent of all university graduates that originate from non-urban or rural regions and chose to start working in urban regions the year after graduation remain in an urban region after five years. After 10 years that figure is still about 70 percent, and just somewhat lower after an

additional five years. We also observe that those graduates who made a similar first location choice, but who originate from urban regions, are significantly more likely to remain in urban regions over time. We conclude that a focus on the first location choice subsequent graduation is warranted since this choice is lasting; a vast majority of those moving to an urban region after they studied keep their choice of working in an urban region even 15 years after the first choice was made.

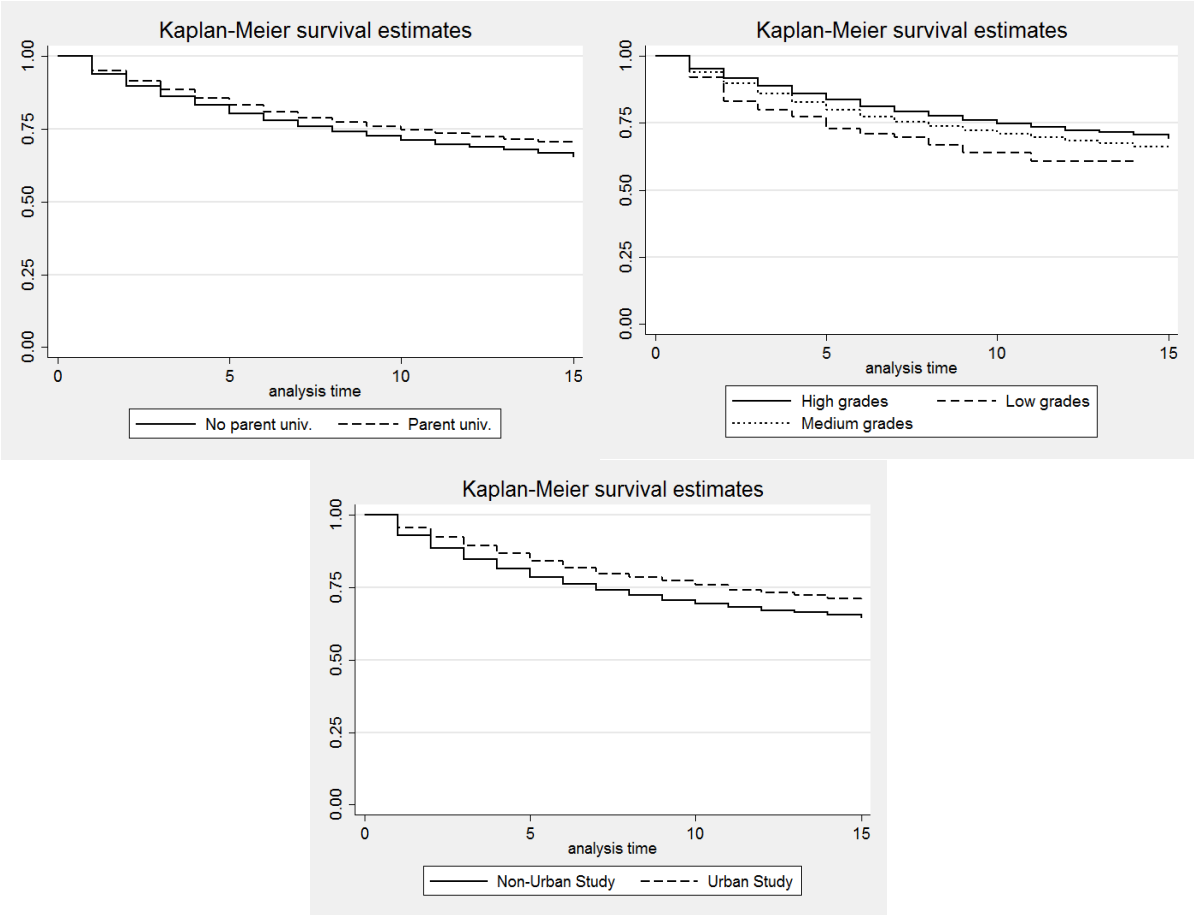

Figure 3. *Longevity in the choice of locating in urban regions subsequent graduation, university graduates in Sweden 1995-2009*

Consistent with our Heckman Probit results, there is also a marked pattern of 'brain drain' from non-urban to urban regions in terms of who stays in urban regions. Figure 3 shows the longevity of the first choice of locating in an urban region for graduates with non-urban origin, and makes a distinction between graduates with and without at least one parent with a university degree (upper left panel) and between graduates with below, average and above average high school grades (upper right panel), and who studied in urban and non-urban regions, respectively. Among graduates with non-urban origin who started to work in urban regions, those who studied in urban regions are more likely to remain in urban regions. This is consistent with the general results from the Heckman Probit estimations.

It is also clear that among the same group of graduates, those that come from families with a stronger educational background and who have better grades from high school are more likely to remain in urban regions over time. This comes to show that sorting does not only manifest in terms of who is most likely to start working in urban regions subsequent graduation, but also in terms of who stays in urban regions over extended periods of time.[8]

6. SUMMARY AND CONCLUSIONS

It is well known that highly educated individuals are more likely to sort themselves to urban regions. Less is understood about the characteristics of this sorting process in terms of when it occurs and who it involves. Many studies inadvertently assume that it occurs at the time of labor market entry and focus on movements educated workers between regions, or the number of college graduates in regions of varying density.

We confirm a clear sorting process where graduates with better high-school grades and from families with a strong educational background are more likely to start their labor market career in urban regions, even if they grew up and went to high school in rural regions. Sorting of workers towards urban regions is thus not only about individuals with longer education being more likely to choose urban regions as their residence. Within the group of university educated, those with stronger indicators of latent abilities that are valued in the labor market show a higher preference for urban regions.

A significant part of this sorting process begins well before labor market entry, already when prospective students decide where to study. The overall pattern of the sorting process that emerges is one of rural-to-urban brain drain where the 'best and brightest' leave for urban regions already in the decision where to study and remain in such regions for work. For instance, our estimates imply that, among university graduates that grew up in the rural parts of Sweden, 10 percent higher average high school grades increase the probability of studying in urban regions with over 5 percentage points. Still, even after accounting for the first-stage selection to university studies, among graduates from rural areas that studied in urban regions, those with 10 percent higher grades are 1.2 percentage points more likely to remain in urban regions for work subsequent graduation.

[8]To verify the broad patterns observed in Figure 3, we also ran a simple Cox proportional hazard model in which we estimated the influence that grades, parents' education and urban study have on the hazard rate, while controlling for age, gender and other basic individual characteristics control variables. These estimations confirmed that grades, parents' education levels and urban study location all had a negative and statistically significant influence on the hazard, i.e. lowering the "risk" of leaving an urban region, even when all variables were included simultaneously together with basic controls.

We also show that sorting does not only manifest in terms of who is most likely to start working in urban regions subsequent graduation, but also in terms of who stays in urban regions over extended periods of time. The longevity of the initial choice to work in an urban region post-graduation is positively correlated with having better high school grades and coming from a family with stronger study tradition, further exacerbating ability sorting to urban regions.

One implication of our results is that analyses of sorting based on movements of people in the labor market may understate sorting to urban regions, because such analyses risk not capturing sorting occurring before labor market entry. The results also point to that the initial flows of graduates to universities are pre-determined by the historical geography of top universities and education institutions that are often located in urban regions.

All in all, our results are consistent with the so-called escalator function of big cities (Fielding 1992, Gordon 2015), where young and ambitious educated workers move to career opportunities in large urban regions. Such a process is clearly consistent with the broad patterns of directed sorting of university graduates we found evidence of in this paper. However, moving to opportunity also involves moving to good universities for study which are often found in the large cities. There is, thus, a twofold opportunity in the larger urban regions; study and work.

There are several avenues for further research along the lines in this paper. One is further analyses using a more fine-grained delineation of geography and recognizing possible interdependencies between urban and rural areas. In this paper we intentionally used a coarse distinction between urban and non-urban regions as our interest was in the broad patterns of sorting. As pointed out by e.g. Irwin et al (2010), however, urban vs. no-urban is much more than a dichotomy. There are urban-rural interdependencies and a continuum from urban to more remote places, and the sorting process could certainly look different depending on the type of rural or non-urban region and its closeness to urban areas. Other avenues for further analyses include more in-depth analyses of possible differences in sorting with respect to different subjects of study and the labor market prospects in various places, as well as further analyses of how the initial location subsequent graduation may change during the life course and how characteristics of individuals and life events, such as family formation, may influence this choice. One area of particular interest, not least for rural policy, concerns the ‘when’ and ‘who’ of people eventually moving back to rural regions, as well as what characterizes rural regions managing to bring back educated workers later in their life.

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