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ABSTRACT

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This paper examines the causal impact of education on within-country migration. A major higher education reform took place in Finland in the 1990s. It gradually transformed former vocational colleges into polytechnics and expanded higher education to all regions. The reform created exogenous variation in the regional supply of higher education. Using the reform as an instrument, our estimation results show that polytechnic graduates have a 7.5 (13.7) percentage points higher migration probability during a three-year (six-year) follow-up period than vocational college graduates.

JEL Classification: J10, J61, I20, R23

Keywords: migration, higher education, vocational education, polytechnic education, school reform

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1. Introduction

Unemployment is notoriously high and persistent in Europe. Within-country migration is one of the few mechanisms that still positively contribute to the adjustment towards equilibrium in the labour market. This is important, because the European economies are facing paramount structural problems that require incessant turnover of workers both across industries and regions in order to improve the allocation of labour. Even this mechanism will be compromised in future, because the population is ageing rapidly in Europe. As the population become older, the average migration intensity decreases,[1] which tends to further worsen the mismatch between unemployed job seekers and available vacancies.

But at the same time, the population in Europe is also becoming more educated than ever. The young age cohorts that enter the labour market are much more educated than the old age cohorts that exit it. Assuming that the migration intensity is increasing with the level of education, the ongoing expansion of the share of highly educated persons can counterbalance the negative effects of population ageing on the efficiency of matching in the labour market, at least to some degree.[2]

Although the relationship between education and migration has been studied in the extensive earlier literature, only the empirical studies by Machin et al. (2012), Malamud and Wozniak (2012), and McHenry (2013) have taken advantage of policy reforms to examine the causal effect of education on within-country migration. The results are inconclusive. Using a Norwegian primary school reform, Machin et al. (2012) find that the length of compulsory education has a *positive* causal impact on migration. They show that one additional year of education increases the annual migration rates by 15 per cent from a low base rate of one per cent per year. In contrast to the results in

[1] Molloy et al. (2011) argue that ageing of the population could result in declining migration rates in the U.S.

[2] In addition, evidence suggests that high home ownership produces negative 'externalities' upon the labour market, reducing labour mobility (Blanchflower & Oswald, 2013).

Machin et al. (2012), McHenry (2013) reports that additional schooling at low education levels has a significant *negative* effect on migration in the U.S. context, exploiting variation in schooling due to compulsory schooling laws. Furthermore, Malamud and Wozniak (2012) use variation in college attainment in the U.S. caused by draft-avoidance behaviour during the Vietnam War. Their results imply that the additional years of higher education significantly increased the likelihood that the affected men, later in life, resided outside the states where they had been born. Taken at face value, previous research suggests that the effect of educational attainment on migration is likely to vary according to the level of education.

This paper exploits the polytechnic education reform that took place in Finland in the 1990s. The aim is to estimate the causal effect of educational attainment on within-country migration. The reform gradually transformed former vocational colleges into polytechnics that offered a Bachelor's degree and expanded the supply of higher education to all regions. In a nutshell, the reform brought higher education to regions that did not have a university in the pre-reform system. The reform is particularly policy-relevant, because it increased the share of persons with higher education. The school reforms often aim exactly at this in the advanced countries. With this paper, therefore, we provide evidence of whether education has an effect on subsequent migration at the upper part of the education distribution. We use the number of new polytechnic study places in the region of residence as an instrument for graduating from a polytechnic. The analyses are based on rich longitudinal data on graduated high school students. Using this setting, we find that obtaining a polytechnic degree instead of a vocational degree causally increases the probability of migration. Our estimates also reveal that this effect is notably larger in the long run. The quantitative magnitude of this effect is substantial at 13.7 percentage points over a six-year follow-up period (7.5 in the first three years).

Our paper is also related to the literature that has studied non-pecuniary outcomes of additional schooling. The evidence is, for example, mounting in favour of the existence of a causal relationship leading from higher education to better health (Cutler & Lleras-Muney, 2008) and various domains of satisfaction (Oreopoulos & Salvanes, 2011). For example, Oreopoulos and Salvanes (2011) estimate that as much as three-quarters of the positive effect of schooling on life satisfaction can be attributed to non-pecuniary factors. From this broader perspective, the potential effects on migration behaviour constitute another unintended non-pecuniary outcome of education.

The paper is organised as follows. Section 2 discusses the theoretical arguments that link education to migration. Section 3 describes the polytechnic education reform. Section 4 introduces the data. Section 5 describes the empirical approach that allows us to control for unobserved heterogeneity by the joint estimation of education and migration decision. The results are reported in Section 6, and the last section concludes.

2. Theoretical links between education and migration

Following the seminal work by Sjaastad (1962), migration is regarded as a means of investing in human capital (see also Becker, 1964, 1993; Bodenhöfer, 1967). Heterogeneous individuals have different utility functions and, consequently, encounter differences in the net (monetary and non-monetary) benefits of living in a specific location. In this framework, individuals move to other locations if their expected future benefits of migration exceed its costs. Consequently, interregional mobility is necessary to bring higher expected returns to individual human capital investments.

The positive correlation between education and migration constitutes a well-known stylised fact in the empirical literature. For example, Borjas's (2013, p. 321) labour economics textbook documents a higher migration rate across the U.S. states for college graduates than for high school graduates. Ehrenberg and Smith (2009, p. 327) even regard education as "the single best indicator of who will move *within* an age group"; see also reviews by Greenwood (1975, 1997).[3]

Several theoretical explanations have been proposed for the positive relationship.[4] Many of these relate to job search. The first one is the existence of a greater earnings differential between regions – thus greater potential benefits from moving – for the highly educated (Armstrong & Taylor, 2000, p. 155). Education is a form of general human capital, which is easily transferable to different geographical locations. For example, Levy and Wadycki (1974) found that the highly educated are more responsive to wages in alternative locations.[5] In related research, Wozniak (2010) has shown that the highly educated are also more responsive to local labour demand.

Second, education increases a person's capability of obtaining and analysing employment information, and of using more sophisticated modes of information and search methods (Greenwood, 1997, p. 406). Hence, highly educated workers may have better access to information about job prospects and living conditions in other regions.

Third, a higher level of educational attainment may open up new opportunities in the labour market (e.g. Greenwood, 1997, p. 406; see also McCormick, 1997). As education improves, skills become more portable and the market for individual occupations at each level of education tends to become geographically wider but quantitatively smaller in a given location (Schwartz, 1973, p. 1160). For example, the market for cashiers is local, and many are needed; on the other hand, relatively fewer nuclear scientists are needed but their market is international.

[3] In Finland, the relationship between education and migration has been studied by Ritsilä and Ovaskainen (2001); see also Pekkala and Tervo (2002), Hämäläinen and Böckerman (2004) and Haapanen and Ritsilä (2007) for more general studies of Finnish migration patterns.
[4] There are several individual-level characteristics such as risk-taking preferences that arguably correlate with education but are not controlled for in the traditional migration equations. For this reason, the existing literature offers little guidance about whether education has an independent effect on migration or not.
[5] They argue that the highly educated are more mobile, primarily because they have better access to information and greater incentives to make additional investments in a search of better opportunities.

Fourth, psychic costs resulting from the agony of departure from family and friends are likely to decrease with education (Schwartz, 1973). Higher educational groups are more homogeneous over space in terms of their culture and manners. Therefore, they are more receptive to new environments. Education may also reduce the importance of tradition and family ties and increase the individual's awareness of other localities and cultures. Greenwood (1975, p. 406) argues that the risk and uncertainty of migrating may be lesser for the better educated because they are more likely to have a job prior to moving. Therefore, a higher level of education may also moderate the income risks associated with migration. That being said, higher education may also expand an individual's local networks and provide increased labour market stability (e.g. less risk of unemployment, shorter unemployment spells and higher earnings). This increases the opportunity costs of moving and thus reduces the necessity to move to another region (see Farber, 2004; McHenry, 2013, p. 38).

However, simultaneity of the relationship between education and the psychic costs of migration should not be overlooked (Schwartz, 1973). The attitude toward the psychic costs of migration may also, in part, contribute to the amount of formal education that individuals wish to complete. *Ceteris paribus*, those with lower psychic costs of migration may invest more in their education, because obtaining education requires, in many cases, moving to a new region. That being said, unwillingness to move for work-related reasons may also result in extensive investment in education, if a person lives in a region with good educational opportunities.

For the reasons discussed above, educational attainment is almost always included in the set of variables explaining an individual's migration decision (see e.g. Faggian, McCann, & Sheppard, 2007; Jaeger et al., 2010; Tunali, 2000). Still, some authors maintain that education affects migration only through its impact on earnings (see Eliasson, Nakosteen, Westerlund, & Zimmer, 2013; Falaris, 1988, p. 527; Nakosteen, Westerlund, & Zimmer, 2008, p. 777).[6] Regardless of whether the assumption is correct or not, this indirect link provides another possible reason for the positive correlation between education and migration: the higher incomes of professional workers enable them to cover the costs of migration more easily.[7]

In contrast to Machin et al. (2012), Malamud and Wozniak (2012), and McHenry (2013), other analyses use simple statistical models that treat education as exogenously determined. However, education and migration decisions are evidently co-determined by unobserved factors such as personality traits (e.g. willingness to take risks, motivation, patience and conscientiousness) and parental values. Indeed, the endogeneity of the education decision is taken as granted in other fields of research (see Card, 1999). Therefore, most of the preceding estimates can be seriously biased. The size and direction of this bias is not known. Even though education is positively correlated with migration, we do not know whether the significant correlation can be interpreted as a causal effect which is relevant for policy making. Also, the general correlations in the total population do not provide evidence about the effect of education on migration at the upper part of the education distribution. In this paper, we apply an instrumental variables strategy to provide policy-relevant evidence on the causal effect of education on within-country migration. To accomplish this goal, we take advantage of the polytechnic reform that exogenously altered the availability of higher education over time and across regions.

[6] That is, these studies include earnings but not education in their migration equation, which imposes a particularly strong assumption about the mechanism between education and migration.
[7] We do not control for an individual’s income in our models below, because we are interested in the overall effect of education on the propensity to move.

3. The Finnish polytechnic reform

Since the polytechnic education reform the higher education system has comprised two parallel sectors: universities[8] and polytechnics. In essence, the reform brought higher education to regions that did not have a university before the reform.[9] The polytechnic degrees are bachelor-level higher education degrees with a vocational emphasis. These degrees take from three and a half to four years to complete. A major difference between the sectors is that polytechnic schools are not engaged in academic research like universities.

The first 22 polytechnics were established under a temporary licence in 1991 (e.g. Lampinen, 2001). The polytechnics were created by gradually merging 215 vocational colleges and vocational schools. The gradual implementation of the reform is reflected in the fact that students who had started their studies before a particular vocational college transformed itself into a polytechnic continued their studies along the old college lines and they eventually graduated with vocational college degrees. Hence, the timing of the reform varied considerably across schools and regions and provided quasi-exogenous staged variation, as described in Böckerman et al. (2009, p. 674–675). Seven new temporary licences were granted during the 1990s. The first graduates from the new polytechnics entered the labour market in 1995. The experimental phase was judged to be successful and since 1996 the temporary polytechnics have gradually become permanent. Currently there are 27 multidisciplinary polytechnics. Unlike the university sector, the network of polytechnics covers the whole country.

The supply of education is controlled by the Ministry of Education through its decisions on the number of study places and the funding of other schools. The number of applications to universities and to the most popular polytechnics exceeds the number of

[8] The Finnish university sector consists of 20 universities and art academies, all of which carry out research and provide education-awarding degrees up to doctorates. For further details on the university sector, see e.g. Ministry of Education (2005).

[9] More detailed description of the polytechnic education reform is available in Böckerman et al. (2009, p. 674–675).

available places by a factor of four. Until the end of the 1990s polytechnic study places increased very rapidly and vocational college study places decreased accordingly (Figure 1). By 1996 the number of new polytechnic students exceeded the number of new university students, and by the end of the 1990s hardly any new vocational college places were made available.[10]

— Figure 1 around here —

The most important aim of the polytechnic reform was to respond to new demands for vocational skills that were seen to arise in the regional labour markets. The geographically broad network of higher education was also regarded as a means to equalise regional development, for example, by reducing the brain drain from the less developed regions to the metropolitan areas. The polytechnics are located further away from high school graduates than lower-level educational institutions are. Therefore, the polytechnic reform is likely to increase the migration propensities to specialised education after high school. For this reason, it is likely to have an indirect effect on school-to-work migration, because those who have moved in the past are more likely to move again (see e.g. DaVanzo, 1983).

4. Data

The individual-level data are based on the Longitudinal Census File and the Longitudinal Employment Statistics File constructed by Statistics Finland. These two basic register files were updated annually from 1987 to 2006 (and every five years in 1970–1985). By matching individuals' unique personal identifiers across the censuses, these panel data sets provide a variety of reliable, register-based information on the residents of Finland. This means that, contrary to surveys, for example, the comprehensive, register-based data contain a minimal amount of measurement error; cf. Malamud and Wozniak (2012). Furthermore, register data on spouses and the region of

[10] The remaining vocational college lines provide very specialised training that is typically available in only one location.

residence are linked to the individual records. With longitudinal linkages of the data we can also obtain information on the education that the graduates' parents received.

The sample that is used in the estimations comprises a seven per cent random sample of the individuals who resided permanently in Finland in 2001.[11] The sample was further restricted to the individuals who had completed high school (general upper secondary education, "lukio" in Finnish) which ends in matriculation. With a few exceptions, high school is required for tertiary-level (including polytechnic) education. From the population of the matriculated we collected all those (19,537) individuals who had their first graduation from specialised education (upper secondary school, vocational college, polytechnic or university) in 1988–2001.[12]

In the analyses, we consider long-distance migration between the 18 Finnish NUTS3 regions, following e.g. Nivalainen (2004).[13] These migration flows allow us to examine the changes in the geographical distribution of human capital. Focusing on migration between the NUTS3 regions is also practical, because the location of the educational institution where an individual graduates is known at this regional level in the data. Furthermore, migration of shorter distances between municipalities or sub-regions most likely reflects housing market conditions rather than labour market prospects.

Initially we consider the short-run and long-run migration rates that describe the proportion of individuals who move during the graduation year or the following two and five years, respectively. The effects of education on within-country migration are typically estimated in the literature for the total population. The key advantage of focusing on recent graduates is that we avoid the potential complications caused by the

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11 The individuals graduating from the Åland Islands are not included in the sample. Åland is a small isolated region with approximately 26,000 inhabitants. It differs from the other Finnish regions in numerous ways (e.g. most of the inhabitants speak Swedish as their native language).

12 We treat the bachelor's degree as an intermediate phase of the master's degree, because it was very uncommon to finish one's studies with a bachelor's degree from a Finnish university in the 1990s (i.e. before the Bologna process was adopted in 2005). In addition, only individuals graduating at an age less than 35 years are kept in the data.

13 Appendix, Figure A4 shows a map of the NUTS3 regions in Finland.

accumulation of firm-specific human capital on the turnover of workers (cf. Jovanovic, 1979).

Before turning to empirical modelling, it is useful to document that there are considerable differences in the migration rates according to the level of education (Figure 2 and 3).[14] It is a general pattern that the more educated have greater propensity to move. For our analysis, the most important observation is that new polytechnic graduates are more likely to move than vocational graduates before and after the reform. But the migration rates between polytechnic and university graduates do not differ much. The migration patterns are similar in the short run and the long run.

— Figure 2 and 3 around here —

Towards the end of the reform the migration gap between vocational and polytechnic graduates narrows. However, the visual impression can be highly misleading in this respect because there were only a few graduates from specialised vocational schools towards the end of the investigation period (cf. Figure 1 and Figure A1). Interestingly, the cyclical variation in the migration rates is also notably different according to the level of education; there was a sudden drop and a subsequent rapid recovery of the migration rates for university graduates during the depression of the early 1990s (Figure 2). Additionally, the highly educated experienced the decreasing migration rates after 1993–1994.[15]

In the estimation we restrict the analyses to graduates from the reform years 1995–2001, because it is not possible to construct a comparison group within the same year before 1995, since the first polytechnic graduates entered the labour market in 1995. This

[14] Appendix, Figure A3 shows the migration rates after graduation from vocational or polytechnic education by the field of education.

[15] Kaplan and Schulhofer-Wohl (2012, p. 11) document the secular decline in interstate migration in the United States between 1991 and 2011. The migration rates have dropped for individuals with and without a bachelor's degree. They argue that the fall in migration is due to a decline in the geographic specificity of returns to occupations, together with an increase in workers' ability to learn about other locations before moving there, through information technology and inexpensive travel.

sample selection also provides substantial variation in the instrument that is needed for the identification of the endogenous treatment model.

5. Empirical specifications

5.1. Treating education as exogenous

Our purpose is to estimate the (causal) effect of polytechnic education on migration. For comparison, we first assume that the individual's level of education is *exogenously* determined. Namely, we model the migration probability of individual i using the standard binary logit model; that is, we assume that it is determined according to the logistic density function f.

$$\Pr(m_i = 1 \mid \mathbf{x}_i, \mathbf{d}_i) = \frac{\exp(\mathbf{d}_i'\boldsymbol{\gamma} + \mathbf{x}_i'\boldsymbol{\alpha})}{1 + \exp(\mathbf{d}_i'\boldsymbol{\gamma} + \mathbf{x}_i'\boldsymbol{\alpha})} \equiv f(\mathbf{d}_i'\boldsymbol{\gamma} + \mathbf{x}_i'\boldsymbol{\alpha}) \tag{1}$$

where m_i is a dummy variable indicating whether or not (s)he migrates during the follow-up period across NUTS3 regions. The vector $\mathbf{d}_i = [d_{i0}, d_{i1}, d_{i2}, d_{i3}]$ represents an individual's choice between four levels of education d_{ij} after matriculation: upper secondary (j = 0), vocational (j = 1; reference group), polytechnic (j = 2) or master's degree (j = 3).[16] First, we estimate the migration probability for the three-year follow-up period consisting of the graduation year and the following two years, and then we extend the observation period by three years. Later we also consider alternative definitions of the dependent variable.

All the control variables, $\mathbf{x}_i$, are measured in the year before an individual graduates from specialised education after matriculation, so that the consequences of migration are not confused with the causes of migration. This timing difference considerably lessens the likelihood that acquired specialised education could affect the (future) values of the control variables and hence bias the estimates. Following, for example, Greenwood

[16] One of the education dummies, i.e. the dummy for the vocational education, has been dropped from the model. Thus we define, $\gamma_1 = 0$ for identification.

(1997), Nivalainen (2004) and Haapanen and Tervo (2012), we use the standard set of covariates; see the Appendix (Table A1) for the detailed definitions of the control variables and their mean values.

Concerning personal characteristics, we control for age, gender and mother tongue. To account for past migration experience, we use a dummy variable indicating whether a person's graduation region differs from the matriculation region. There is extensive prior literature confirming that individuals who have moved in the past are more likely to move in the future (see e.g. DaVanzo, 1983). Another potential determinant of migration (and the choice of education level) is prior scholastic achievement. Matriculation exam scores[17] from high school are used as the measure of this achievement. It is expected that an individual's ability is positively correlated with migration because of his or her attendance at institutes of higher education, and also for the reasons discussed in Section 2 (e.g. ability is likely to correlate positively with the potential monetary benefits from moving). The data also allow us to distinguish the effect of the education level from the field of education. Household characteristics comprise marital status, having children, a spouse's employment status, labour income and the level of education, and the location of the sample individual's parents at the NUTS3 level. For example, in the absence of a spouse's income level as a control,[18] the differences in the ability to finance the migration costs can partly create the observed positive correlation between education and migration.

Finally, we control for the effects that are specific to the region of matriculation, and the year and the region of the graduation from specialised education. The year fixed effects are used to capture the cyclical fluctuations of within-country migration that are

[17] The matriculation examination is a national compulsory final exam taken by all students who graduate from high school. The answers in each test are first graded by teachers and then reviewed by associate members of the Matriculation Examination Board outside the schools. The exam scores are standardised so that their distribution is the same every year. The range of the matriculation exam scores is 1–6.

[18] We do not include a person's own earnings among the controls because the level of education may already affect the earnings during the study period and, hence, bias the estimates of education on migration.

common to all regions (Milne, 1993; Saks & Wozniak, 2011; Venhorst, Van Dijk, & Van Wissen, 2011). The regional fixed effects pick up all the regional differences in the migration intensity that are stable over time.[19]

5.2. Accounting for endogeneity of education

An obvious limitation of the traditional migration model (1) is the assumption about the exogeneity of the choice of education. Generally, three approaches have often been adopted in observational data to deal with the complication of endogeneity and self-selection: (i) instrumental variables, (ii) control functions, and (iii) full parametric specification of the outcome and treatment equations. In the model defined below, we will follow Deb and Trivedi (2009) and use a combination of the third and first approaches (Deb, Li, Trivedi, & Zimmer, 2006; Deb & Trivedi, 2006). This is particularly useful in our context, because it allows us to generalise a logit model by assuming the joint determination of the choice of education and the migration decision.

Treatment of the education choice as *endogenous* allows us to control for unobserved latent characteristics (e.g. personality traits of individuals such as the attitudes toward risk that are not available even in the rich register-based data), $\mathbf{l}_i = [l_{i0}, l_{i1}, l_{i2}, l_{i3}]$, that affect both education choice and migration decision. Conditional on the latent factors, an individual's choice between the four levels of education, d_{ij} (j= 0, 1, 2, 3), is modelled using the multinomial logit (MNL) model:[20]

$$\begin{aligned} \Pr(d_{ij} = 1 \mid \mathbf{x}_i, z_i, \mathbf{l}_\mathbf{i}) &= \frac{\exp(\mathbf{x}_i'\boldsymbol{\beta}_j + \varphi_j z_i + \delta_j l_{ij})}{\sum_{k=0}^{3} \exp(\mathbf{x}_i'\boldsymbol{\beta}_k + \varphi_k z_i + \delta_k l_{ik})} \\ &\equiv g\left(\{\mathbf{x}_i'\boldsymbol{\beta}_k + \varphi_k z_i + \delta_k l_{ik} : k = 0,1,2,3\}\right) \end{aligned} \quad (2)$$

[19] We have experimented with the unemployment rate and the share of service sector workers at the sub-regional (NUTS4) level as additional controls, but they are not included in the final specifications. The worry is that the students might move during their studies to municipalities that are more attractive in terms of job opportunities and amenities, and commute to education from there. These controls also have limited variation within regions over time. Our robustness checks suggest that their inclusion has only a minor influence on the estimates.

[20] Note that the choice probability for each education alternative j depends on all the parameters of all alternatives.

where $\mathbf{x}_i$ denotes the vector of observed control variables (discussed above). Although the model described above can be technically identified by its functional form, for more robust identification an instrumental variable z_i included in the education choice equation but excluded from the migration equation is needed (see Deb & Trivedi, 2006). δ_j's are parameters associated with the latent factors l_{ij}.

The binary migration decision is again modelled though a logistic density function *f*:

$$\Pr(m_i = 1 \mid \mathbf{x}_i, \mathbf{d}_i, \mathbf{l}_i) = \frac{\exp(\mathbf{d}_i'\boldsymbol{\gamma} + \mathbf{x}_i'\boldsymbol{\alpha} + \mathbf{l}_i'\boldsymbol{\lambda})}{1 + \exp(\mathbf{d}_i'\boldsymbol{\gamma} + \mathbf{x}_i'\boldsymbol{\alpha} + \mathbf{l}_i'\boldsymbol{\lambda})} \equiv f(\mathbf{d}_i'\boldsymbol{\gamma} + \mathbf{x}_i'\boldsymbol{\alpha} + \mathbf{l}_i'\boldsymbol{\lambda}) \tag{3}$$

where the vector representing the education choice $\mathbf{d}_i$ is treated as endogenous. The inclusion of the latent variables $\mathbf{l}_i$ in (3) (and in 2) should eliminate the endogeneity bias.

Our instrument for the level of education, z_i, is the supply of polytechnic education for an individual *i* when matriculating from high school. The supply is measured as the number of new polytechnic study places in the NUTS3 region of residence in the year of matriculation. The identification strategy is based on the assumption about the exogeneity of the polytechnic reform.[21] Consequently, we assume that the supply of polytechnic starting places is exogenously determined after controlling for other factors potentially influencing migration decisions. For the correct identification of the effect of the reform it is, however, not necessary for the supply to be independent of the fixed regional effects, since we control for such factors with a set of fixed dummies.

Since the education and migration choice equations are independent after conditioning on explanatory variables including the common latent factors, the joint probability of individual *i* choosing education level d_{ij} and migration decision m_i is the product of the two respective conditionally independent probabilities:

[21] Regressions predicting the expansion of polytechnics across regions and over time support the exogeneity of the reform (Böckerman & Haapanen, 2013, p. 603).

$$\Pr(m_i, d_{ij} | \mathbf{x}_i, z_i, \mathbf{l}_i) = f(\mathbf{d}_i'\boldsymbol{\gamma} + \mathbf{x}_i'\boldsymbol{\alpha} + \mathbf{l}_i'\boldsymbol{\lambda}) \times g\left(\left\{\mathbf{x}_i'\boldsymbol{\beta}_k + \varphi_k z_i + \delta_k l_{ik} : \forall k\right\}\right) \tag{4}$$

The problem in estimation arises because l_{ij}'s are not observed. However, if we assume a density function h_j for l_{ij}'s then its effect can be integrated out of the joint probability function. In particular, the resulting likelihood function for the joint model is:

$$\begin{aligned} L(m_i, d_{ij} | \mathbf{x}_i, z_i) &= \prod_{i=1}^{N} \int \left[f(\mathbf{d}_i'\boldsymbol{\gamma} + \mathbf{x}_i'\boldsymbol{\alpha} + \mathbf{l}_i'\boldsymbol{\lambda}) \times g\left(\left\{\mathbf{x}_i'\boldsymbol{\beta}_k + \varphi_k z_i + \delta_k l_{ik} : \forall k\right\}\right)\right] h_j(l_{ij})\, \mathrm{d}\, l_{ij} \\ &\approx \prod_{i=1}^{N} \frac{1}{S} \left[\sum_{s=1}^{S} f(\mathbf{d}_i'\boldsymbol{\gamma} + \mathbf{x}_i'\boldsymbol{\alpha} + \tilde{\mathbf{l}}_i'\boldsymbol{\lambda}) \times g\left(\left\{\mathbf{x}_i'\boldsymbol{\beta}_k + \varphi_k z_i + \delta_k \tilde{l}_{ik} : \forall k\right\}\right)\right] \end{aligned} \tag{5}$$

where $\tilde{\mathbf{l}}_i$, $\tilde{l}_{ij}$ contain draws of l_{ij} from density h_j. Here, the densities of the latent factors, h_j, are assumed to follow independent standard normal distributions. This maximum simulated likelihood (MSL) estimator is consistent and asymptotically normal (Gouriéroux & Monfort, 1996). In the estimation, we use S = 3,000 quasi-random draws based on the Halton sequences to increase the speed of convergence (Train, 2009).[22]

Finally, normalisations are required for the identification of the model. First, a normalisation is required on either λ_j or δ_j's because otherwise the variances of the MNL choice equations are not identified (see Deb & Trivedi, 2006). We set δ_j = 1 for each j and estimate the values of λ_j. Second, since $\boldsymbol{\beta}_1 = \mathbf{0}$, $\varphi_1 = 0$ and $\delta_1 = 0$ are required for the normalisation in the MNL model (when vocational education, j = 1, is the reference category), we assume $l_{1j} = 0$ without the loss of generality. Finally, the education dummy for the vocational education $\gamma_1 = 0$ is unidentified as before.

It is well-known that the MNL model has the independence of irrelevant alternative (IIA) property that places restrictions on the underlying structure of preferences.[23] As discussed in Deb and Trivedi (2009), this would be an important limitation if our aim

[22] Deb and Trivedi (2009) recommend using as large draws S as is computationally feasible. They set S = 1,000 in their application. We experimented with smaller (S = 2,000) and larger (S = 4,000) values to confirm the stability of the convergence.
[23] Note, however, that MNL is less restrictive than the ordered logit model that is often used in modelling educational choices.

were to analyse the structure of preferences over discrete alternatives. However, in our setting the main role of the MNL model is to allow us to control for endogeneity of the choice of schooling.

The estimated parameters of the models described above do not directly provide the estimates of the marginal effects of education on the migration decision. To uncover these effects, we simulate the discrete changes in the predicted migration probabilities, μ, by changing the educational attainment but keeping the same background characteristics, $\tilde{\mathbf{x}}$, fixed in the comparison. For example, the treatment effect of polytechnic education vs. vocational education is calculated as[24] $\mu(m=1|\mathbf{d}_2=1;\tilde{\mathbf{x}})-\mu(m=1|\mathbf{d}_2=0;\tilde{\mathbf{x}})$. Because the marginal effects are not constant across individuals, we present them for various hypothetical values of the covariates. First, we define $\tilde{\mathbf{x}}$ with the mean characteristics for all graduates over the period 1995–2001. Later we will also use only the mean and median characteristics of polytechnic and vocational graduates to allow for better comparison of the migration rates between these two levels of education.

6. Results

6.1. Education as exogenous

To begin the analysis of the effect of education on within-country migration, we first assume the exogeneity of the education choice and estimate the migration decision with a logit model using maximum likelihood, following the earlier empirical literature. Because we exploit the polytechnic reform, vocational education is used as the reference group in all models and the sample consists of graduates over the period 1995–2001.

[24] This effect can only be interpreted as the causal effect of education if polytechnic graduates have acquired more education than vocational graduates. Figure A2 in the Appendix shows that polytechnic graduates are, on average, around one year older than vocational graduates, which implies that the vocational colleges were not simply relabelled as polytechnics. We would also expect to find no effect on migration in this case.

Table 1 reports the marginal effects of education on short-run migration.[25] The most parsimonious specification in Column 1 that does not include any controls shows that having a polytechnic education increases the probability of migrating to another NUTS3 region in the short run by 5.2 percentage points. The effect of polytechnic education remains positive but the statistical significance levels are low throughout as we load in controls from Column 2 onwards. These controls have been identified in the literature on migration as standard confounders. The specification in Column 3 that adds an indicator for previous migration for studies gives a notably low point estimate. However, the quantitative magnitude of the effect of polytechnic education on migration remains relatively stable after the addition of further controls (Columns 4–6).

LR-ratio tests clearly reveal that the addition of controls significantly improves the fit of the model. For this reason, the estimates in Column 6 constitute the preferred model specification for short-run migration. Our preferred model shows that the marginal effect of polytechnic education on short-run migration is 2.6 percentage points (13.3%; p-value = 0.068) from the base rate of 19.6 per cent (for those with vocational education). For comparison, Table A2 in Appendix shows the corresponding estimates for the full sample using data on graduates over the period 1988–2001. Our conclusions remain intact but the quantitative magnitude of the marginal effects is higher across the board in Table A2. In the preferred model, polytechnic education increases the migration rates by 3.2 percentage points (16.6%; p-value = 0.012) from the 19.3 per cent.[26]

— Table 1 around here —

Next, we proceed to examine the effects of polytechnic education on long-run migration. The structure of Table 2 is identical to Table 1. In the preferred model

[25] Heteroskedasticity-robust standard errors that are clustered by graduation-region-by-year cells are reported for all models.

[26] We have also computed the marginal effects as averages over all observations (see Cameron & Trivedi, 2005, p. 467). These AMEs are very similar (0.025 and 0.032) to those obtained using the mean characteristics of graduates.

(Column 6) the marginal effect of polytechnic education on long-run migration is 3.5 percentage points (11.9%; *p*-value = 0.028) from the base rate of 26.9 per cent.[27] Thus, the long-run effect is higher in absolute size than the short-run effect (0.035 vs. 0.026) but lower in percentages (11.9% vs. 16.6%). We also observe that the marginal effect of having polytechnic education varies more as we add the controls from Column 2 onwards (Table 2). Therefore, it is more important to use the complete set of controls when we estimate the long-run effect of education on migration. Again the addition of controls is supported by LR-ratio tests and the preferred specification is reported in Column 6. Table A3 in the Appendix documents the corresponding estimates for the full sample, using graduates over the period 1988–2001. As in Table 1 vs. Table A2, the effect of polytechnic education on migration is estimated to be higher (at 0.042; 15.8%; *p*-value = 0.004) in the full sample (Table A3) compared to the restricted sample in Table 2.[28]

— Table 2 around here —

6.2. Education as endogenous

The estimates in Tables 1–2 treat the education choice as an exogenous variable. This assumption is not realistic, because there are both theoretical and empirical reasons to treat the education choice as an endogenous variable in the estimated model. In particular, there are likely to be unobservable factors such as personality traits that are correlated both with the education choice and the subsequent migration behaviour of graduates that were not controlled for in Tables 1–2 with the standard vector of covariates. This implies that our baseline results in Tables 1–2 do not constitute unbiased (causal) estimates for the effect of polytechnic education on migration. For

[27] Average unemployment rate was 3.5 per cent lower for polytechnic graduates (23.9%) than for vocational graduates (24.8%) at the end of the graduation year in 1996-1999. But the range of unemployment rates across NUTS3 regions was much higher (+29.8%) for polytechnic graduates than for vocational graduates. In contrast, in the UK the unemployment rates of highly educated workers are relatively similar across regions. Larger regional differences in the unemployment rates in Finland provide one mechanism through which education increases migration.

[28] In the Appendix, Table A4 and A5, we report the robustness of the short-run and long-run marginal effects to alternative specifications of the control variables.

this reason, there is an apparent need to estimate specifications that account for the endogenous education choice and to empirically evaluate the validity of the conclusions based on the exogeneity assumption.

To accomplish this goal, we estimate the equations for the education choice and migration jointly, as described in Section 5.2. Table 3 reports the estimation results for the education choice equations. These results are based on the joint estimation of the choice between four levels of education and short-run migration.[29] (The results for long-run migration are almost similar.) As previously, the table reports the estimates for three levels of education while treating vocational education as the reference group. In the models that account for the endogenous education choice we use the supply of polytechnic education in a person's matriculation region (NUTS3) as the identifying instrument. This implies that the variable is included in the education choice equation but is excluded from the migration equation. The instrument is a highly statistically significant (p-value < 0.001) explanatory variable for the graduation from a polytechnic, as documented in Column 2 of Table 3. This positive correlation confirms the relevance of the instrument. We also find some support that the supply of polytechnic education in the matriculation region decreases the probability of graduating from university (the estimate is negative but not significant). This result is reasonable, because both the university sector and polytechnics provide higher education. Thus, they are substitutes for each other.

Table 3 also reveals some other interesting patterns of the education choice that we summarise only briefly. We find that a person's completed level of education increases monotonically with the matriculation exam score. Thus, those who have better (measured) ability tend to obtain a higher level of formal education, other things being

[29] We also estimated the education choice equations separately to investigate the IIA assumption. Two Hausman tests using a subset of alternatives resulted in negative test statistics, and the third resulted in a positive, insignificant one. Hence, the tests do not support the rejection of the IIA assumption (see Hausman & McFadden, 1984, p. 1226).

equal. The parameter estimate of the matriculation exam score is particularly high for completing Master's degree. The other important finding that is also directly linked to migration behaviour is that university students are particularly prone to migrate prior to entering education. Again the observed pattern is plausible, because university education is available in fewer regions than upper secondary, vocational or polytechnic education is. For this reason, there is a much greater to need to migrate in order to obtain university education.

— Table 3 around here —

Table 4 documents the determinants of both short-run and long-run migration in the models where the education choice is treated as endogenous. We report both the estimated parameters and the corresponding marginal effects. These results reveal that there is more evidence for selection into education on the basis of unobserved heterogeneity in the long-run model for migration than in the short-run model. This pattern is reasonable, because graduates' observable characteristics such as marital status and having children are measured immediately before their graduation. Therefore, they are able to account for better behaviour shortly after graduation. LR-ratio tests show that the coefficients (λ's) of the latent factors (i.e. unobserved characteristics) are jointly statistically significant in the long-run model (p = 0.087).[30] In contrast, in the short-run model the coefficients of the latent factors are not jointly statistically significant but the latent factor for upper secondary and polytechnic education points to the existence of considerable unobserved heterogeneity.

— Table 4 around here —

The selection effects have a considerable impact on the quantitative magnitudes of the estimated coefficients on the education variables of the migration equations when the

[30] The estimated negative coefficients (λ's) suggest that there are some latent factors (such as conscientiousness) that correlate positively with level of education and negatively with migration intensity. These latent factors are not accounted for in the logit models that assume exogenous education choice.

joint estimator is applied (Table 4). The most important finding is that the variable of interest (i.e. polytechnic education) remains positive and is statistically significant at the 10 per cent level in all models. But it is also useful to compare the quantitative magnitude of the estimates that are based on the exogeneity and endogeneity assumption. After accounting for the endogeneity of the education choice both short-run and long-run effects are significantly larger than in the logit models that assume strict exogeneity (cf. Tables 1–2). This is a natural implication from the estimated negative λ's. Note, however, that the effect of polytechnic education on migration is still estimated to be smaller than the effect of university education both in the short run and long run (Table 4). Previous studies have also found IV estimates to be larger than those assuming exogenous schooling choice (see Machin et al., 2012; Malamud & Wozniak, 2012).

Importantly, also when the effects are jointly estimated, the marginal effect of polytechnic education on subsequent migration is larger in the long run (0.131; *p*-value = 0.037) than in the short run (0.071; *p*-value = 0.058). Exactly the same pattern prevails for the other levels of education as well. Reassuringly, the estimated impacts of the exogenous covariates in Table 4 are in accordance with the prior literature on migration. Note also that the matriculation examination score is strongly positively related to migration both in the short and long run. This result implies that graduates with better (measured) ability are more likely to migrate, even conditional on completed education.

Table 5 displays the heterogeneity of the treatment effect of polytechnic vs. vocational education on migration. These marginal effects are now calculated using only the characteristics of the vocational and polytechnic graduates. The most important finding is that the earlier reported patterns remain intact, i.e. polytechnic education has a significantly larger positive effect on migration in the long run (0.137) than in the short run (0.075). We also observe that conditional on the median characteristics of the graduates the effect of polytechnic education on migration is considerably smaller when the mean characteristics are used.[31] The median region in the data is Uusimaa, where the population share is the highest of all NUTS3 regions in Finland (28%) and where the Helsinki metropolitan area is located. Because the local labour markets are much thicker in Uusimaa compared to other regions, it is relatively easy for graduates in Uusimaa to find a job without migrating to other regions because of more effective matching between job seekers and available vacancies. To give a more detailed picture of the geographical variation in the estimated effects, the marginal effects for all NUTS3 regions are depicted in Figure A4. The lower estimates for Uusimaa are striking.

— Table 5 around here —

6.3. Extensions

Table 6 reports the effect of polytechnic education on migration using alternative instrumental variables (Panels A–C) and alternative specifications of the dependent variable (Panels D–F).[32] Overall, the long-run effects are again consistently larger (in absolute size) in all extensions of the model than the short-run effects. Accounting for the endogeneity of the education decision is also more important in the long run, i.e. unobserved latent characteristics are jointly significant in most of the long-run models.

The polytechnic reform can be used in several alternative ways to construct an instrument for an individual's education. One convenient way to measure the availability of polytechnic education is to use the number of polytechnic institutions in the matriculation region. We found that this instrument is statistically stronger when the number of permanent polytechnics is used instead of temporary or all polytechnics. Reassuringly, the results remained intact (Panel A). A frequently used instrument for a person's educational attainment is her/his parent's education (see e.g. Lemke &

[31] The distributions of the individual-level treatment effects are also considerably skewed (cf. Deb & Trivedy 2009). Sample medians are larger than the means in both cases (short-run and long-run migration).

[32] See the Appendix, Table A6, for a description of the variables used only in the robustness checks.

Rischall, 2003). The effect of polytechnic education on within-country migration changes only slightly when we use the father's education dummies as additional instruments (Panel B). This stability of the estimated effects is encouraging,[33] although the use of parental education as an instrument has been criticised by Card (1999, p. 1822-1826) on the ground that parental education often directly affects labour market outcomes such as earnings or is at least correlated with the error term.

Finally, we altered the definition of migration. In Panel C we report the results for migration between 79 NUTS4 sub-regions, instead of NUTS3 regions, and in Panel D for longer-distance migration between the four NUTS2 regions.[34] The estimated long-run marginal effects are now considerably smaller than in the baseline. Thus, increased migration was mostly between the NUTS3 regions. The short-run effect of polytechnic education is insignificant when using migration between NUTS4 or NUTS2 regions and living in the matriculation region as the outcome variable. Only the effect on living in the graduation region after the follow-up period is statistically significant in the short run (Panel E). The long-run effects are significant at the 5–10 per cent level in Panels C–F.

— Table 6 around here —

7. Conclusions

The positive relationship between education and migration is taken as granted in much of the literature. But the actual empirical evidence that there is a causal effect of education on within-country migration is very limited. Only recently has economic research addressed this issue (Machin et al., 2012; Malamud & Wozniak, 2012; McHenry, 2013). But the existing causal estimates are inconclusive and the evidence

[33] Unfortunately the tests of over-identifying restrictions have been not developed for this empirical framework.

[34] In terms of land area, the Finnish NUTS2 regions are larger compared to the EU average and smaller compared to the US states: the Finnish average is 60,895 km^2, the EU average is 15,869 km^2, and the US state average is 183,637 km^2. In 2010, the population density was 18 inhabitants per km^2 in Finland, 117 in the EU and 35 in the US. Sources: Eurostat (2007, 2011), US Census Bureau (2012).

about the effects at the upper part of the education distribution on migration is even thinner.

In this paper, we examined the effects of the availability of education and the level of education on within-country migration using comprehensive longitudinal data. A major higher education reform took place in Finland in the 1990s. This quasi-exogenous staged reform gradually transformed former vocational colleges into polytechnics and expanded higher education to all regions. We exploited the polytechnic education reform to identify the causal effect of education on the migration of the young adults who had graduated from specialised education after matriculation.

Consistent with Malamud and Wozniak (2012), our estimation results show that polytechnic graduates have a 7.5 (13.7) percentage points higher migration probability during a 3-year (6-year) follow-up period than vocational college graduates. This implies that the expansion of education improves the allocation of labour across regions. Therefore, the significant positive effects of the reform on labour market outcomes such as employment and earnings, reported in Böckerman et al. (2009), may have resulted partly from an increase in within-country migration. Interpreted from a broader perspective, our results provide evidence that the expansion of higher education mitigates the adverse effects of population ageing on the efficiency of matching in the labour market.

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TABLES

Table 1. Short-run marginal effects of education on migration (exogenous education choice)

	(1)	(2)	(3)	(4)	(5)	(6)
Upper secondary degree	-0.0422**	-0.0435***	-0.0393***	-0.0495***	-0.0451***	-0.0415***
	(0.0213)	(0.0128)	(0.0134)	(0.0139)	(0.0146)	(0.0147)
Polytechnic degree	0.0510	0.0259*	0.0222	0.0287*	0.0263*	0.0262*
	(0.0341)	(0.0141)	(0.0145)	(0.0149)	(0.0146)	(0.0144)
Master's degree	0.0748***	0.1318***	0.1138***	0.0989***	0.1136***	0.1041***
	(0.0234)	(0.0145)	(0.0147)	(0.0157)	(0.0160)	(0.0162)
Regional and year dummies[a]	no	yes	yes	yes	yes	yes
Migration for studies	no	no	yes	yes	yes	yes
Field of education	no	no	no	yes	yes	yes
Other individual-level controls	no	no	no	no	yes	yes
Family-level controls	no	no	no	no	no	yes
Log-likelihood	-5,856.81	-5,145.80	-5,031.47	-5,020.33	-4,973.71	-4,785.35
LR-test over restricted specification	–	p < 0.001 (df = 40)	p < 0.001 (df = 1)	p < 0.001 (df = 3)	p < 0.001 (df = 6)	p < 0.001 (df = 6)

Notes: Number of observations is 9,906 in all models (i.e. graduates from 1995–2001). Dependent variable: NUTS3 migration during the graduation year or the following two years. Reference level of education is vocational degree. Marginal effects are calculated at mean values of other explanatory variables using logit model. Controls are defined in Appendix, Table A1. Heteroskedasticity-robust standard errors reported in parentheses allow for clustering on the matriculation-year-by-region cells. df = degrees of freedom. [a] Include dummies for the matriculation region, graduation region and graduation year. *** p<0.01, ** p<0.05, * p<0.1.

Table 2. Long-run marginal effects of education on migration (exogenous education choice)

	(1)	(2)	(3)	(4)	(5)	(6)
Upper secondary degree	-0.0284	-0.0298**	-0.0239*	-0.0349**	-0.0386**	-0.0341**
	(0.0217)	(0.0134)	(0.0141)	(0.0147)	(0.0158)	(0.0163)
Polytechnic degree	0.0465	0.0297**	0.0257	0.0332**	0.0351**	0.0351**
	(0.0369)	(0.0151)	(0.0158)	(0.0160)	(0.0156)	(0.0160)
Master's degree	0.0657***	0.1326***	0.1137***	0.0988***	0.1332***	0.1240***
	(0.0252)	(0.0176)	(0.0179)	(0.0186)	(0.0189)	(0.0193)
Regional and year dummies[a]	no	yes	yes	yes	yes	yes
Migration for studies	no	no	yes	yes	yes	yes
Field of education	no	no	no	yes	yes	yes
Other individual-level controls	no	no	no	no	yes	yes
Family-level controls	no	no	no	no	no	yes
Log-likelihood	-6,404.85	-5,632.05	-5,518.76	-5,507.12	-5,446.75	-5,257.89
LR-test over restricted specification	–	p < 0.001 (df = 40)	p < 0.001 (df = 1)	p < 0.001 (df = 3)	p < 0.001 (df = 6)	p < 0.001 (df = 6)

Notes: Number of observations is 9,906 in all models (i.e. graduates from 1995–2001). Dependent variable: NUTS3 migration during the graduation year or the following two years. Reference level of education is vocational degree. Marginal effects are calculated at mean values of other explanatory variables using logit model. Controls are defined in Appendix, Table A1. Heteroskedasticity-robust standard errors reported in parentheses allow for clustering on the matriculation-year-by-region cells. df = degrees of freedom. [a] Include dummies for the matriculation region, graduation region and graduation year. *** p<0.01, ** p<0.05, * p<0.1.

Table 3. Parameter estimates from education choice equations (endogenous education choice; vocational degree as reference)

	Upper secondary degree	Polytechnic degree	Master's degree
Migrated for studies	-0.0513	0.2081	0.5158**
	(0.2194)	(0.2281)	(0.2444)
Technology	1.8765***	0.1092	0.2215
	(0.3259)	(0.2013)	(0.1541)
Health care	1.3822***	0.0555	-1.3513***
	(0.2847)	(0.1940)	(0.1526)
Other fields of education	2.7054***	-1.3430***	0.9396***
	(0.2838)	(0.1786)	(0.1197)
Age	-4.4340***	3.5117***	7.1410***
	(0.2368)	(0.3374)	(0.3882)
Age squared	8.0745***	-6.5435***	-12.1970***
	(0.4486)	(0.6766)	(0.7062)
Female	-0.0979	0.3239***	0.0263
	(0.0977)	(0.1005)	(0.1154)
Swedish	-0.2737	-0.3159	0.3275
	(0.1853)	(0.3165)	(0.2787)
Matricul. result	-0.3413***	0.3826***	1.7930***
	(0.0353)	(0.0440)	(0.0712)
Married	0.6363***	-0.5825***	-1.3326***
	(0.1977)	(0.1773)	(0.2043)
Sp. empl.	-0.1260	-0.1248	-0.4022***
	(0.1424)	(0.1730)	(0.1463)
Sp. educ.	-0.2019**	0.3265***	0.6617***
	(0.0816)	(0.0760)	(0.0778)
Sp. income	0.0049	-0.0589	-0.1283*
	(0.0876)	(0.0734)	(0.0740)
Children	0.3327*	-0.4569***	-0.8046***
	(0.2006)	(0.1745)	(0.1694)
Parents' location	0.2347	0.1857	0.2616
	(0.1891)	(0.1955)	(0.2021)
Supply of polytechnic education	0.0738	0.1265***	-0.1640
	(0.0467)	(0.0358)	(0.1187)
Regional and year dummies	yes	yes	yes

Notes: Number of observations is 9,906 (i.e. graduates from 1995–2001). Results are based on joint estimation of choice between the four levels of education and short-run migration. Likelihood is simulated with 3,000 quasi-random draws based on Halton sequences. Reference education is vocational degree. Choice-specific constants and dummy for matriculation exam score not missing are not reported for brevity. See Appendix, Table A1 for definitions of variables. Heteroskedasticity-robust standard errors reported in parentheses allow for clustering on the matriculation-year-by-region cells. *** p<0.01, ** p<0.05, * p<0.1.

Table 4. Determinants of short-run and long-run migration (endogenous education choice)

	Short-run migration		Long-run migration	
	Parameter estimate	Marginal effect	Parameter estimate	Marginal effect
Upper secondary degree	0.0016	0.0002	0.2315	0.0394
	(0.2135)	(0.0291)	(0.2901)	(0.0474)
Polytechnic degree	0.4531*	0.0713*	0.6843*	0.1308**
	(0.2378)	(0.0377)	(0.3598)	(0.0629)
Master's degree	0.6962***	0.1176***	0.8583***	0.1703***
	(0.1631)	(0.0274)	(0.2388)	(0.0390)
Migrated for studies	0.7931***	0.1233***	0.8159***	0.1459***
	(0.1576)	(0.0292)	(0.1686)	(0.0316)
Technology	-0.0676	-0.0091	-0.1489	-0.0231
	(0.0950)	(0.0124)	(0.1114)	(0.0153)
Health care	0.0027	0.0004	-0.0323	-0.0051
	(0.0861)	(0.0117)	(0.1000)	(0.0157)
Other fields of education	0.2390**	0.0335**	0.2098*	0.0341*
	(0.1128)	(0.0167)	(0.1202)	(0.0204)
Age	0.5843**	0.0795**	0.3900	0.0621
	(0.2479)	(0.0326)	(0.2755)	(0.0405)
Age squared	-1.1934***	-0.1623***	-0.8621*	-0.1372*
	(0.4578)	(0.0600)	(0.5191)	(0.0749)
Female	-0.0453	-0.0062	-0.0615	-0.0098
	(0.0678)	(0.0093)	(0.0678)	(0.0109)
Swedish	-0.1995	-0.0255	-0.2164	-0.0324
	(0.1517)	(0.0183)	(0.1513)	(0.0205)
Matricul. result	0.0833**	0.0113**	0.0753**	0.0120**
	(0.0360)	(0.0050)	(0.0361)	(0.0059)
Married	-0.7657***	-0.0980***	-0.7827***	-0.1174***
	(0.1550)	(0.0202)	(0.1904)	(0.0205)
Sp. empl.	-0.1902	-0.0250	-0.2447*	-0.0374*
	(0.1339)	(0.0174)	(0.1367)	(0.0202)
Sp. educ.	0.0390	0.0053	0.0518	0.0082
	(0.0575)	(0.0078)	(0.0581)	(0.0087)
Sp. income	-0.3202***	-0.0436***	-0.2683***	-0.0427***
	(0.0846)	(0.0113)	(0.0732)	(0.0107)
Children	0.1287	0.0182	-0.0283	-0.0045
	(0.1361)	(0.0201)	(0.1287)	(0.0202)
Parents' location	-0.5767***	-0.0861***	-0.6412***	-0.1115***
	(0.1752)	(0.0273)	(0.1979)	(0.0287)
λ (Upper secondary degree)	-0.3856		-0.5509	
	(0.2486)		(0.3739)	
λ (Polytechnic degree)	-0.3623		-0.6280	
	(0.2696)		(0.4213)	
λ (Master's degree)	-0.1174		-0.2713	
	(0.1735)		(0.2305)	
Regional and year dummies	Yes		Yes	
Log-likelihood	-12,543.74		-13,014.44	
LR-test for joint significance of latent factors	p = 0.406 (df = 3)		p = 0.087 (df = 3)	

Notes: Number of observations is 9,906 in all models (i.e. graduates from 1995–2001). Dependent variable: NUTS3 migration during the graduation year or the following two years. Results are based on joint estimation of choice between the four levels of education and short-run migration. Likelihood is simulated with 3,000 quasi-random draws based on Halton sequences. Reference level of education is vocational degree. Marginal effects are calculated at mean values of other explanatory variables using logit model. Controls are defined in Appendix, Table A1. Estimates for dummy of matriculation exam score not missing are not reported for brevity. Heteroskedasticity-robust standard errors reported in parentheses allow for clustering on the matriculation-year-by-region cells. df = degrees of freedom. *** p<0.01, ** p<0.05, * p<0.1.

Table 5. Marginal effects of polytechnic education on short-run and long-run migration: Heterogeneity

	Short-run migration		Long-run migration	
	Exogenous educ. choice	Endogenous educ. choice	Exogenous educ. choice	Endogenous educ. choice
Mean	0.0276*	0.0753*	0.0365**	0.1373**
	(0.0151)	(0.0394)	(0.0166)	(0.0665)
	[0.2109]	[0.1752]	[0.2888]	[0.2161]
Median	0.0096*	0.0284*	0.0153**	0.0602**
	(0.0053)	(0.0155)	(0.0069)	(0.0244)
	[0.0599]	[0.0540]	[0.9111]	[0.0705]
Graduation region				
Uusimaa	0.0090*	0.0227**	0.0150**	0.0473***
	(0.0050)	(0.0115)	(0.0069)	(0.0167)
Other regions	0.0354*	0.0987*	0.0420**	0.1642*
	(0.0193)	(0.0518)	(0.0191)	(0.0840)

Notes: Number of observations is 9,906 in all models (i.e. graduates from 1995–2001). Marginal effects have been calculated using only characteristics of the vocational and polytechnic graduates (mean or median). Coefficient shows the treatment effect of polytechnic vs. vocational education on migration. Results are based on models reported in Tables 3–4. Heteroskedasticity-robust standard errors reported in parentheses allow for clustering on the matriculation-year-by-region cells. *** p<0.01, ** p<0.05, * p<0.1. Predicted migration probabilities for the mean and median individuals conditional on vocational degree are reported in square brackets.

Table 6. Marginal effects of polytechnic education on short-run and long-run migration: Extensions

	Short-run migration		Long-run migration		
	Exogenous educ. choice	Endogenous educ. choice	Exogenous educ. choice	Endogenous educ. choice	
Baseline					
For model reported in Tables 3–4	0.0276*	0.0753*	0.0365**	0.1373**	†
	(0.0151)	(0.0394)	(0.0166)	(0.0665)	
Alternative instrumental variables					
Panel A: Number of permanent polytechnics in the matriculation NUTS3 region	0.0276*	0.0782*	0.0365**	0.1449**	†
	(0.0151)	(0.0407)	(0.0166)	(0.0731)	
Panel B: Father's level of education and supply of polytechnic education	0.0276*	0.0741*	0.0365**	0.1419**	†
	(0.0151)	(0.0381)	(0.0166)	(0.0661)	
Changing dependent variable					
Panel C: NUTS4 (shorter-distance) migration	0.0173	0.0378	0.0284	0.0849*	
	(0.0166)	(0.0368)	(0.0190)	(0.0441)	
Panel D: NUTS2 (longer-distance) migration	0.0068	0.0408	0.0111	0.0779*	‡
	(0.0107)	(0.0301)	(0.0129)	(0.0402)	
Panel E: Living in the graduation region after follow-up period	-0.0299**	-0.0695*	-0.0340**	-0.0870**	
	(0.0133)	(0.0363)	(0.0156)	(0.0428)	
Panel F: Living in the matriculation region after follow-up period	-0.0274	-0.0722	-0.0450**	-0.1050**	†
	(0.0179)	(0.0363)	(0.0185)	(0.0501)	

Notes: Number of observations is 9,906 in all models (i.e. graduates from 1995–2001). Marginal effects have been calculated using mean characteristics of the vocational and polytechnic graduates in the graduation region. Coefficient shows the treatment effect of polytechnic vs. vocational education on migration. Variables are defined in Appendix, Table A1 and A6. Heteroskedasticity-robust standard errors reported in parentheses allow for clustering on the matriculation-year-by-region cells. *** $p<0.01$, ** $p<0.05$, * $p<0.1$. ‡ (†) jointly significant latent factors at 0.05 (0.1) risk level.

FIGURES

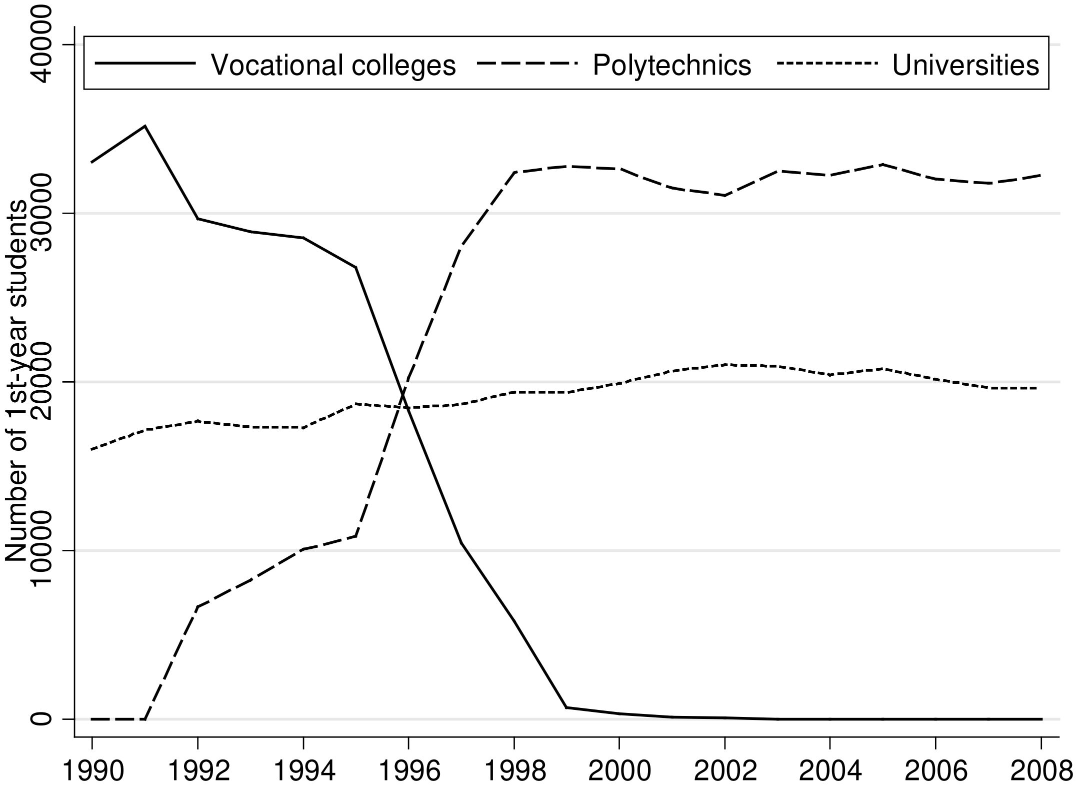

Figure 1. New vocational, polytechnic and university students in Finland 1990–2008.

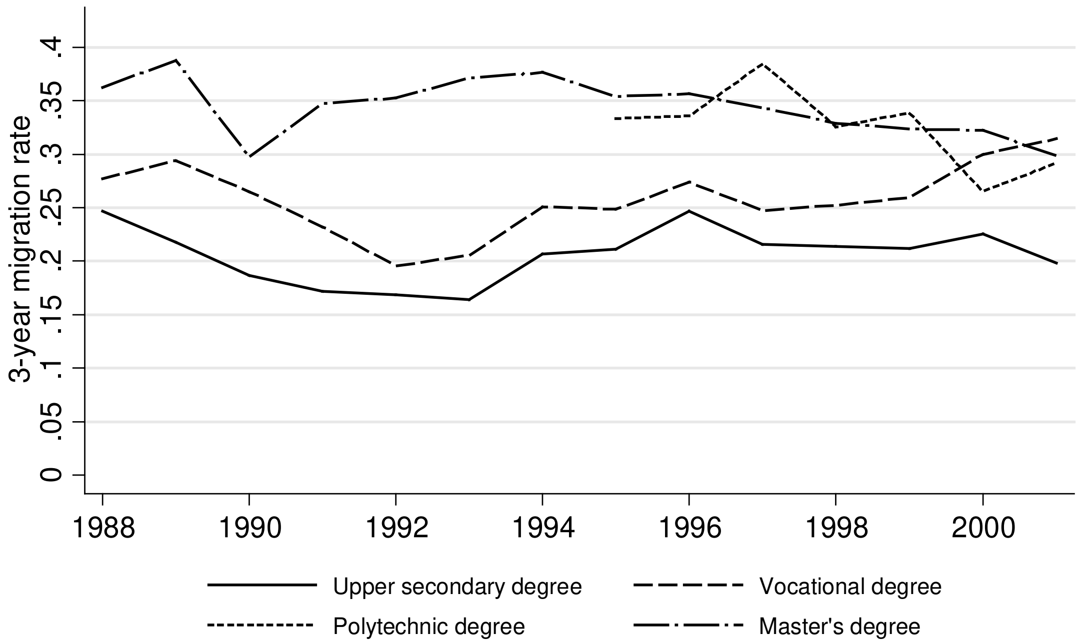

Figure 2. Three-year migration rates after graduation from the first specialised education. Note: See Figure A1 for the number of graduates at different levels of education.

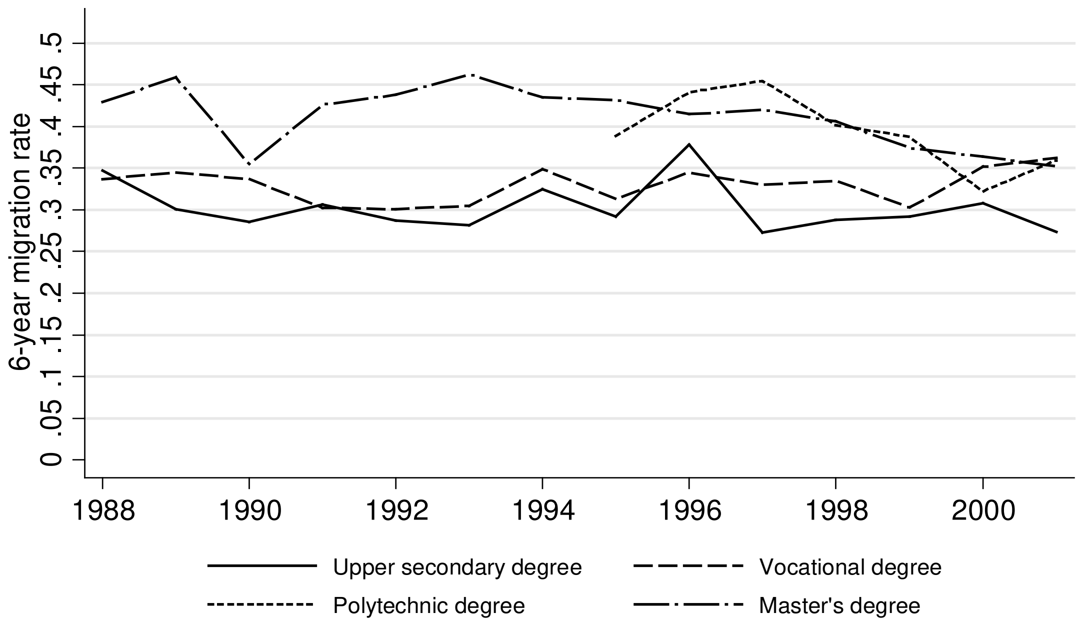

Figure 3. Six-year migration rates after graduation from the first specialised education. Note: See Figure A1 for the number of graduates at different levels of education.

APPENDIX

Table A1. Description of covariates and their mean values for the two samples

	Description	(1)	(2)
Dependent variables			
Short-run migration	1 if person migrates between NUTS3 regions during the graduation year or the following two years, 0 otherwise	0.2752	0.2840
Long-run migration	1 if person migrates between NUTS3 regions during the graduation year or the following five years, 0 otherwise	0.3527	0.3538
Level of education			
Upper secondary degree	1 if the 1st degree after high school is upper secondary, 0 otherwise	0.2410	0.2267
Vocational degree	1 if the 1st degree after high school is vocational, 0 otherwise (reference category)	0.3330	0.2354
Polytechnic degree	1 if the 1st degree after high school is polytechnic, 0 otherwise	0.0935	0.1844
Master's degree	1 if the 1st degree after high school is master's, 0 otherwise	0.3325	0.3534
Instrument			
Supply of polytechnic education	Number of 1st year polytechnic students in the NUTS3 region during the year of matriculation (1,000 students)	0.3995	0.7740
Control variables			
Matriculation region	Regional dummies (18) indicate the NUTS3 region where person matriculates	–	–
Graduation region	Regional dummies (18) indicate the NUTS3 region where person graduates from specialised education after high school	–	–
Graduation year	Year dummies (1988–2001) indicate when person graduates from specialised education after high school	–	–
Migrated for studies	1 if person's graduation NUTS3 region (1st degree) differs from the matriculation NUTS3 region; 0 otherwise	0.1904	0.2434
Business	1 if the field of education business, administration and social sciences; 0 otherwise (reference category)	0.2859	0.2590
Technology	1 if the field of education technology or transport; 0 otherwise	0.2113	0.2168
Health care	1 if the field of education health care or welfare; 0 otherwise	0.1886	0.2002
Other fields	1 if the field of education is something else; 0 otherwise	0.3142	0.3239
Age	Age in years	24.668	24.862
Age squared	Age/10 squared	6.1736	6.2667
Female	1 if female, 0 if male	24.657	24.820
Swedish	1 if person belongs to the Swedish minority, 0 otherwise	6.1631	6.2409
Matricul. result	General grade from matriculation exam. Range from 1 (lowest grade) to 6 (highest grade). 0 if missing	0.6063	0.6055
Matr. result not miss.	1 if matriculation result is not missing, 0 otherwise	0.0474	0.0472
Married	1 if married or cohabiting, 0 otherwise	0.3319	0.3731
Sp. empl.	1 if spouse is employed, 0 otherwise	0.1588	0.2309
Sp. educ.	Spouse's level of education (0 if no spouse, 1 if comprehensive educ.,…, 5 if higher tertiary educ.)	0.8283	0.9378
Sp. income	Annual income of spouse, 10,000 €	0.3999	0.4493
Children	1 if children under 18 years in the family, 0 otherwise	0.0779	0.0777
Parents' location	1 if graduated from a NUTS3 region where either of the parents was living, 0 otherwise	0.7939	0.7410
Number of observations		19,537	9,906

Notes: Control variables are measured on a year before an individual graduates from the first specialised education after high school. Sample includes: (1) Full sample of graduates from 1988–2001; (2) Restricted sample of graduates from 1995–2001.

Table A2. Short-run marginal effects of education on migration (exogenous education choice, full sample)

	(1)	(2)	(3)	(4)	(5)	(6)
Upper secondary degree	-0.0400***	-0.0460***	-0.0445***	-0.0579***	-0.0481***	-0.0443***
	(0.0121)	(0.0073)	(0.0076)	(0.0079)	(0.0085)	(0.0083)
Polytechnic degree	0.0623*	0.0370***	0.0330**	0.0333**	0.0320**	0.0320**
	(0.0321)	(0.0127)	(0.0129)	(0.0130)	(0.0126)	(0.0127)
Master's degree	0.0981***	0.1530***	0.1373***	0.1254***	0.1430***	0.1318***
	(0.0164)	(0.0096)	(0.0098)	(0.0108)	(0.0114)	(0.0111)
Regional and year dummies[a]	no	yes	yes	yes	yes	yes
Migration for studies	no	no	yes	yes	yes	yes
Field of education	no	no	no	yes	yes	yes
Other individual-level controls	no	no	no	no	yes	yes
Family-level controls	no	no	no	no	no	yes
Log-likelihood	-11,342.42	-10,152.37	-10,032.42	-10,009.18	-9,920.47	-9,590.10
LR-test over restricted specification	–	p < 0.001 (df = 47)	p < 0.001 (df = 1)	p < 0.001 (df = 3)	p < 0.001 (df = 6)	p < 0.001 (df = 6)

Notes: Number of observations is 19,537 in all models. Dependent variable: NUTS3 migration during the graduation year or the following two years. Reference level of education is vocational degree. Marginal effects are calculated at mean values of other explanatory variables using logit model. Controls are defined in Appendix, Table A1. Heteroskedasticity-robust standard errors reported in parentheses allow for clustering on the matriculation-year-by-region cells. df = degrees of freedom. [a] Include dummies for the matriculation region, graduation region and graduation year. *** p<0.01, ** p<0.05, * p<0.1.

Table A3. Long-run marginal effects of education on migration (exogenous education choice, full sample)

	(1)	(2)	(3)	(4)	(5)	(6)
Upper secondary degree	-0.0213	-0.0288***	-0.0264***	-0.0417***	-0.0416***	-0.0369***
	(0.0135)	(0.0090)	(0.0093)	(0.0095)	(0.0100)	(0.0101)
Polytechnic degree	0.0504	0.0418***	0.0373***	0.0385***	0.0419***	0.0424***
	(0.0349)	(0.0141)	(0.0144)	(0.0144)	(0.0143)	(0.0148)
Master's degree	0.0859***	0.1555***	0.1394***	0.1253***	0.1639***	0.1543***
	(0.0175)	(0.0116)	(0.0117)	(0.0125)	(0.0132)	(0.0132)
Regional and year dummies[a]	no	yes	yes	yes	yes	yes
Migration for studies	no	no	yes	yes	yes	yes
Field of education	no	no	no	yes	yes	yes
Other individual-level controls	no	no	no	no	yes	yes
Family-level controls	no	no	no	no	no	yes
Log-likelihood	-12,595.49	-11,200.93	-11,086.15	-11,068.81	-10,961.05	-10,616.68
LR-test over restricted specification	–	p < 0.001 (df = 47)	p < 0.001 (df = 1)	p < 0.001 (df = 3)	p < 0.001 (df = 6)	p < 0.001 (df = 6)

Notes: Number of observations is 19,537 in all models. Dependent variable: NUTS3 migration during the graduation year or the following two years. Reference level of education is vocational degree. Marginal effects are calculated at mean values of other explanatory variables using logit model. Controls are defined in Appendix, Table A1. Heteroskedasticity-robust standard errors reported in parentheses allow for clustering on the matriculation-year-by-region cells. df = degrees of freedom. [a] Include dummies for the matriculation region, graduation region and graduation year. *** p<0.01, ** p<0.05, * p<0.1.

Table A4. Robustness checks of the short-run marginal effects of education on migration (exogenous education choice)

	(1)	(2)	(3)	(4)	(5)	(6)
Upper secondary degree	-0.0415***	-0.0451***	-0.0405***	-0.0402***	-0.0396***	-0.0384***
	(0.0147)	(0.0142)	(0.0144)	(0.0147)	(0.0143)	(0.0143)
Polytechnic degree	0.0262*	0.0253*	0.0278*	0.0271*	0.0298**	0.0305**
	(0.0144)	(0.0142)	(0.0142)	(0.0143)	(0.0143)	(0.0142)
Master's degree	0.1041***	0.1149***	0.1062***	0.1058***	0.1186***	0.1201***
	(0.0162)	(0.0172)	(0.0159)	(0.0160)	(0.0167)	(0.0165)
Log-likelihood	-4,785.35	-4,777.49	-4,774.02	-4,780.59	-4,760.15	-4,755.94

Notes: Number of observations is 9,906 in all models (i.e. graduates from 1995–2001). Dependent variable: NUTS3 migration during the graduation year or the following two years. Reference level of education is vocational degree. Column (1) shows baseline reported in Table 1 (column 6); In column (2) field of education is defined with eight categories instead of four; In column (3) migrated for studies dummy is replaced with living in the province of birth dummy; In column (4) other regional-level controls are added; In column (5) earnings prior graduation is added; In column (6) both other regional-level controls and earnings prior graduation are added to the baseline. Marginal effects are calculated at the mean values of other explanatory variables using logit model. Controls are defined in Appendix, Table A1. Heteroskedasticity-robust standard errors reported in parentheses allow for clustering on the matriculation-year-by-region cells. *** p<0.01, ** p<0.05, * p<0.1.

Table A5. Robustness checks of the long-run marginal effects of education on migration (exogenous education choice)

	(1)	(2)	(3)	(4)	(5)	(6)
Upper secondary degree	-0.0341**	-0.0391**	-0.0329**	-0.0323**	-0.0326**	-0.0309*
	(0.0163)	(0.0159)	(0.0159)	(0.0163)	(0.0160)	(0.0160)
Polytechnic degree	0.0351**	0.0340**	0.0375**	0.0361**	0.0395**	0.0404**
	(0.0160)	(0.0158)	(0.0157)	(0.0159)	(0.0160)	(0.0158)
Master's degree	0.1240***	0.1356***	0.1271***	0.1260***	0.1396***	0.1414***
	(0.0193)	(0.0204)	(0.0190)	(0.0191)	(0.0201)	(0.0200)
Log-likelihood	-5,257.89	-5,250.06	-5,239.38	-5,252.96	-5,233.92	-5,229.38

Notes: Number of observations is 9,906 in all models (i.e. graduates from 1995–2001). Dependent variable: NUTS3 migration during the graduation year or the following two years. Reference level of education is vocational degree. Column (1) shows baseline reported in Table 1 (column 6); In column (2) field of education is defined with eight categories instead of four; In column (3) migrated for studies dummy is replaced with graduated from the region of birth dummy; In column (4) other regional-level controls are added; In column (5) earnings prior graduation is added; In column (6) both other regional-level controls and earnings prior graduation are added to the baseline. Marginal effects are calculated at the mean values of other explanatory variables using logit model. Controls are defined in Appendix, Table A1. Heteroskedasticity-robust standard errors reported in parentheses allow for clustering on the matriculation-year-by-region cells. df = degrees of freedom. *** p<0.01, ** p<0.05, * p<0.1.

Table A6. Description of variables used only in the extensions and robustness checks

	Description	(1)	(2)
Dependent variables			
Short-run NUTS4 migration	1 if person migrates between NUTS4 regions during the graduation year or the following two years, 0 otherwise	0.3372	0.3465
Long-run NUTS4 migration	1 if person migrates between NUTS4 regions during the graduation year or the following five years, 0 otherwise	0.4289	0.4315
Short-run NUTS2 migration	1 if person migrates between NUTS2 regions during the graduation year or the following two years, 0 otherwise	0.1856	0.1945
Long-run NUTS2 migration	1 if person migrates between NUTS2 regions during the graduation year or the following five years, 0 otherwise	0.2411	0.2456
In graduation region two years after	1 if living in the graduation region two years after finishing specialised education; 0 otherwise	0.7459	0.7377
In graduation region five years after	1 if living in the graduation region five years after finishing specialised education; 0 otherwise	0.6944	0.6963
In matriculation region two years after	1 if living in the matriculation region two years after finishing specialised education; 0 otherwise	0.6462	0.6190
In matriculation region five years after	1 if person is living in the graduation region five years after finishing specialised education; 0 otherwise	0.6099	0.5967
Instruments			
No. of permanent polytechnics	Number of permanent polytechnics in the NUTS3 region during the year of matriculation	0.1084	0.2137
Father's level of education	Father's level of education with five dummies; basic education as the reference category	–	–
Control variables			
Field of education detailed	Field of education is defined with eight categories instead of the four categories.	–	–
Graduate from the region of birth	1 if person graduates from the NUTS3 region of birth; 0 otherwise	0.6811	0.6462
Unemployment rate	Unemployment rate in the NUTS4 region (i.e. travel-to-work area), %	11.984	16.198
Amenities	Service sector workers in the NUTS4 region, %	5.8530	6.1428
Earnings	Annual earnings subject to state taxation, 10,000 €	0.6524	0.7662
Number of observations		19,537	9,906

Notes: Control variables are measured on a year before an individual graduates from the first specialised education after high school. Sample includes: (1) Full sample of graduates from 1988–2001; (2) Restricted sample of graduates from 1995–2001.

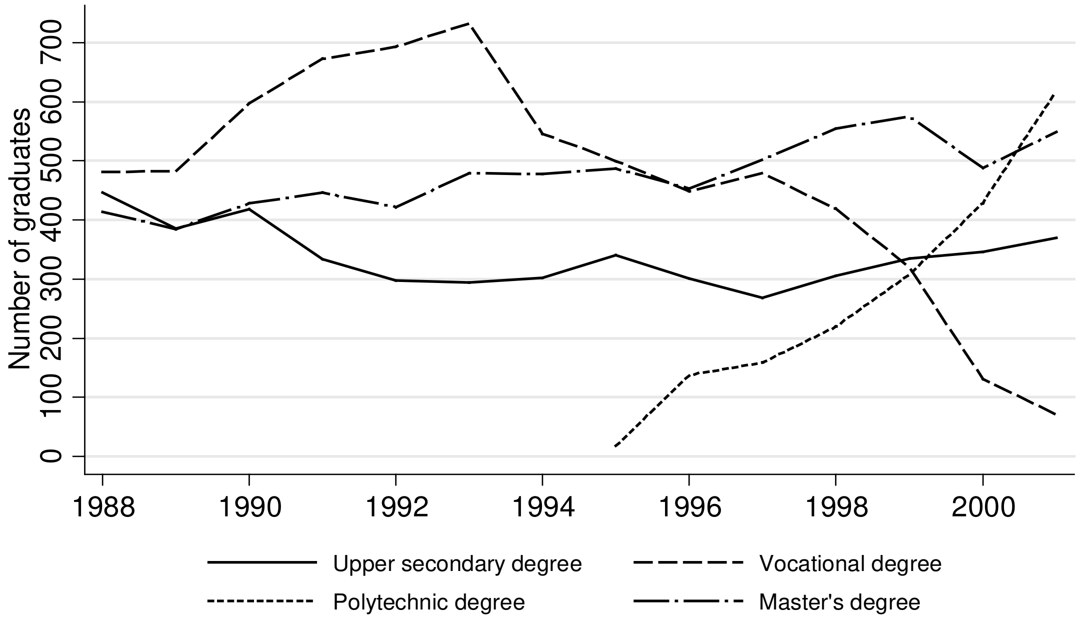

Figure A1. Number of graduates from the first specialised education in 1988–2001 (sample data).

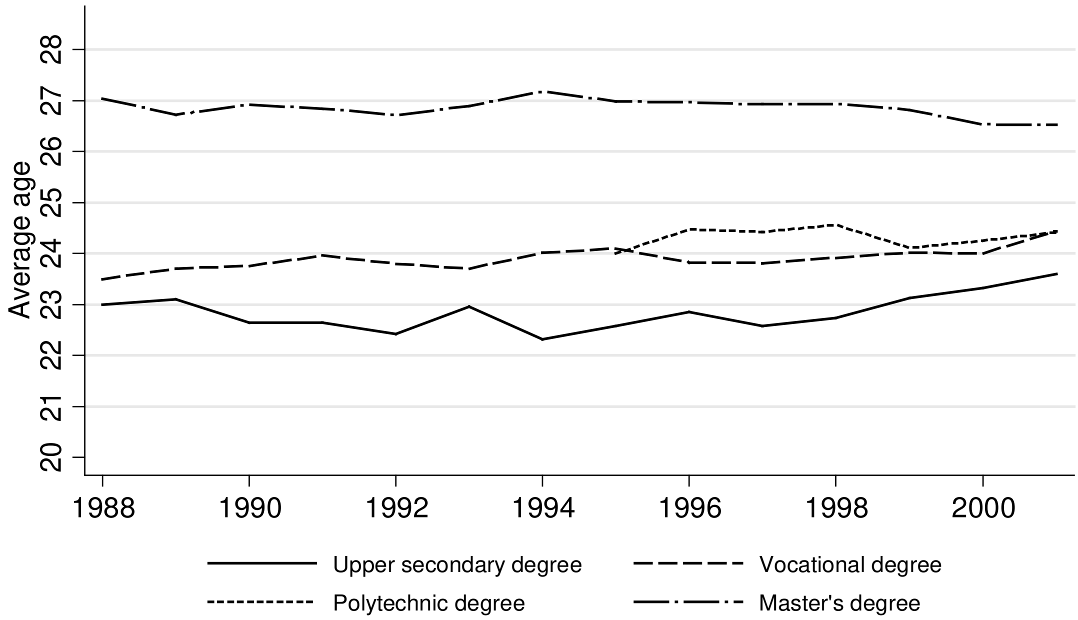

Figure A2. Average age at the first graduation after high school (sample data).

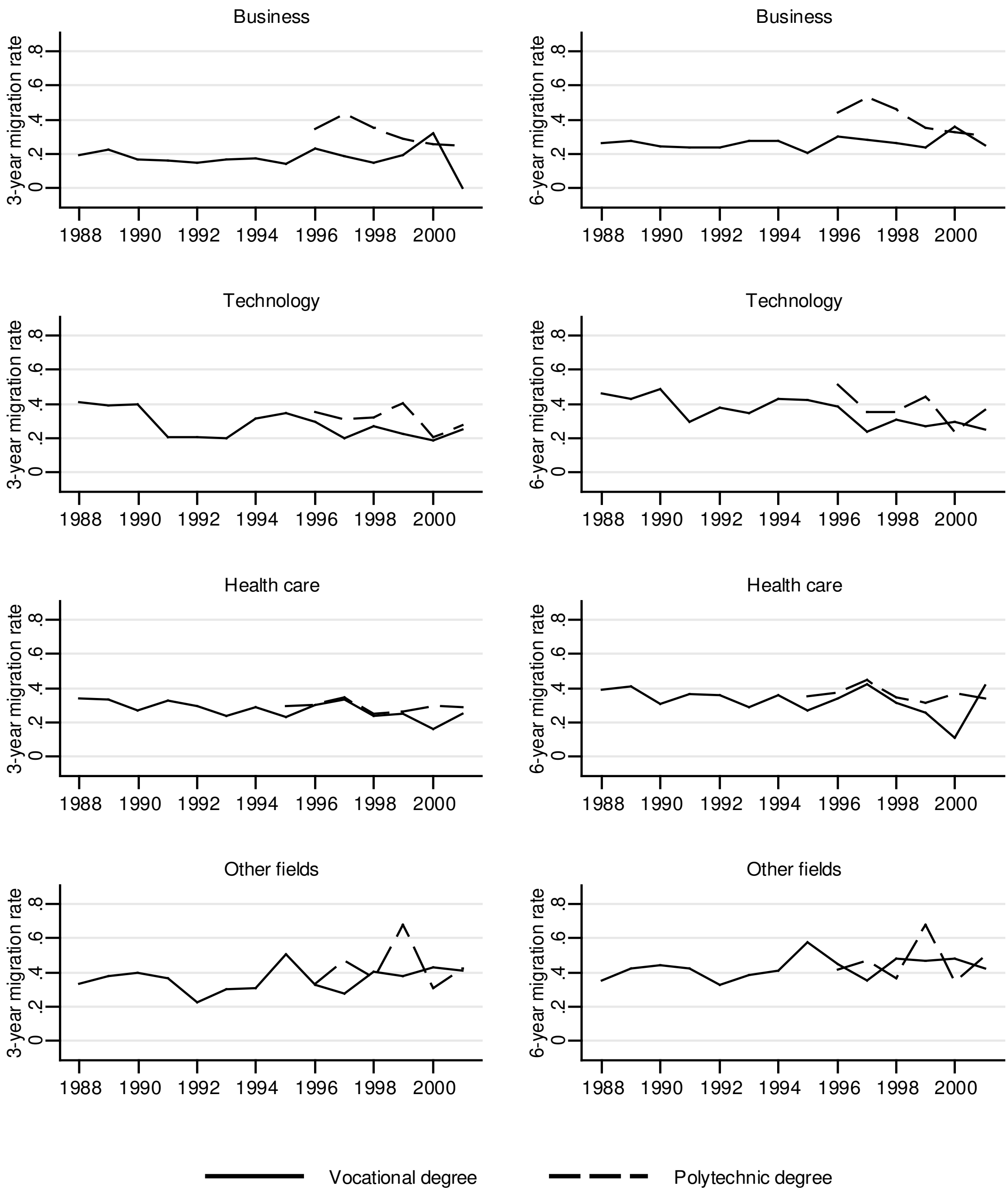

Figure A3. Short-run and long-run migration rates after graduation from vocational or polytechnic degree in 1998–2001: Descriptive statistics by the field of education (sample data).

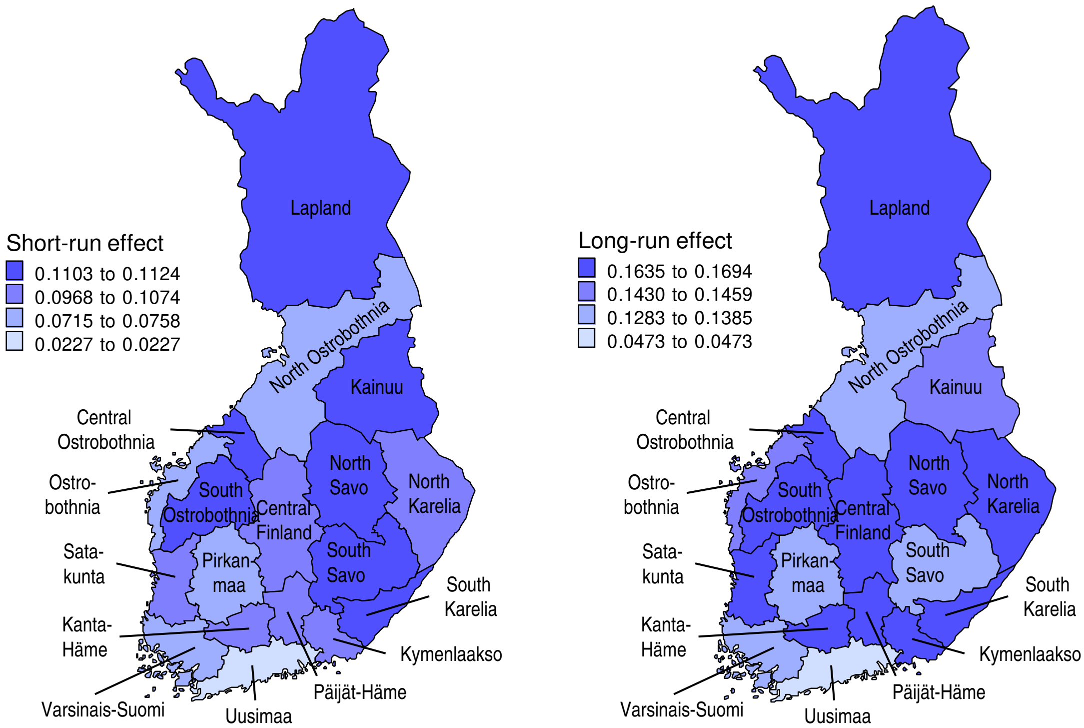

Figure A4. Marginal effects of polytechnic education on short-run and long-run migration: Regional differences. *Notes*: Marginal effects have been calculated using the joint model of education and migration choice reported in Tables 3–4 and the averages of the characteristics of the vocational and polytechnic graduates in the NUTS3 region.

WEB APPENDIX

Table W1. Marginal effects of polytechnic education on short-run and long-run migration: Heterogeneity by graduation region

Graduation region	Short-run migration		Long-run migration	
	Exogenous educ. choice	Endogenous educ. choice	Exogenous educ. choice	Endogenous educ. choice
Uusimaa	0.0090*	0.0227**	0.0150**	0.0473***
	(0.0050)	(0.0115)	(0.0069)	(0.0167)
Varsinais-Suomi	0.0264*	0.0720*	0.0344**	0.1283**
	(0.0148)	(0.0384)	(0.0160)	(0.0626)
Satakunta	0.0370*	0.1031*	0.0426**	0.1664*
	(0.0201)	(0.0538)	(0.0193)	(0.0852)
Kantahäme	0.0380*	0.1074*	0.0429**	0.1694*
	(0.0207)	(0.0568)	(0.0195)	(0.0874)
Pirkanmaa	0.0277*	0.0758*	0.0355**	0.1334**
	(0.0150)	(0.0399)	(0.0161)	(0.0645)
Päijät-Häme	0.0376*	0.1049*	0.0428**	0.1675*
	(0.0203)	(0.0546)	(0.0193)	(0.0859)
Kymenlaakso	0.0373*	0.1051*	0.0428**	0.1686*
	(0.0203)	(0.0552)	(0.0194)	(0.0870)
Central Finland	0.0345*	0.0968*	0.0421**	0.1657*
	(0.0188)	(0.0517)	(0.0191)	(0.0857)
South Karelia	0.0393*	0.1113*	0.0426**	0.1684*
	(0.0214)	(0.0586)	(0.0193)	(0.0861)
North Karelia	0.0375*	0.1053*	0.0429**	0.1692*
	(0.0203)	(0.0556)	(0.0195)	(0.0873)
South Savo	0.0391*	0.1111*	0.0365**	0.1385**
	(0.0212)	(0.0572)	(0.0163)	(0.0642)
North Savo	0.0392*	0.1108*	0.0428**	0.1691*
	(0.0213)	(0.0581)	(0.0194)	(0.0871)
Ostrobothnia	0.0279*	0.0758*	0.0377**	0.1430**
	(0.0153)	(0.0398)	(0.0172)	(0.0704)
South Ostrobothnia	0.0394*	0.1116*	0.0429**	0.1694*
	(0.0214)	(0.0583)	(0.0194)	(0.0873)
Central Ostrobothnia	0.0395*	0.1118*	0.0428**	0.1693*
	(0.0215)	(0.0584)	(0.0194)	(0.0873)
North Ostrobothnia	0.0266*	0.0715*	0.0356**	0.1310**
	(0.0150)	(0.0375)	(0.0164)	(0.0623)
Kainuu	0.0385*	0.1103*	0.0370**	0.1459**
	(0.0211)	(0.0573)	(0.0169)	(0.0721)
Lapland	0.0396*	0.1124*	0.0416**	0.1635**
	(0.0215)	(0.0588)	(0.0189)	(0.0825)

Notes: Number of observations is 9,906 in all models (i.e. graduates from 1995–2001). Marginal effects have been calculated using mean characteristics of the vocational and polytechnic graduates in the graduation region. Coefficient shows the treatment effect of polytechnic vs. vocational education on migration. Results are based on models reported in Tables 3–4. Heteroskedasticity-robust standard errors reported in parentheses allow for clustering on the matriculation-year-by-region cells. *** p<0.01, ** p<0.05, * p<0.1.

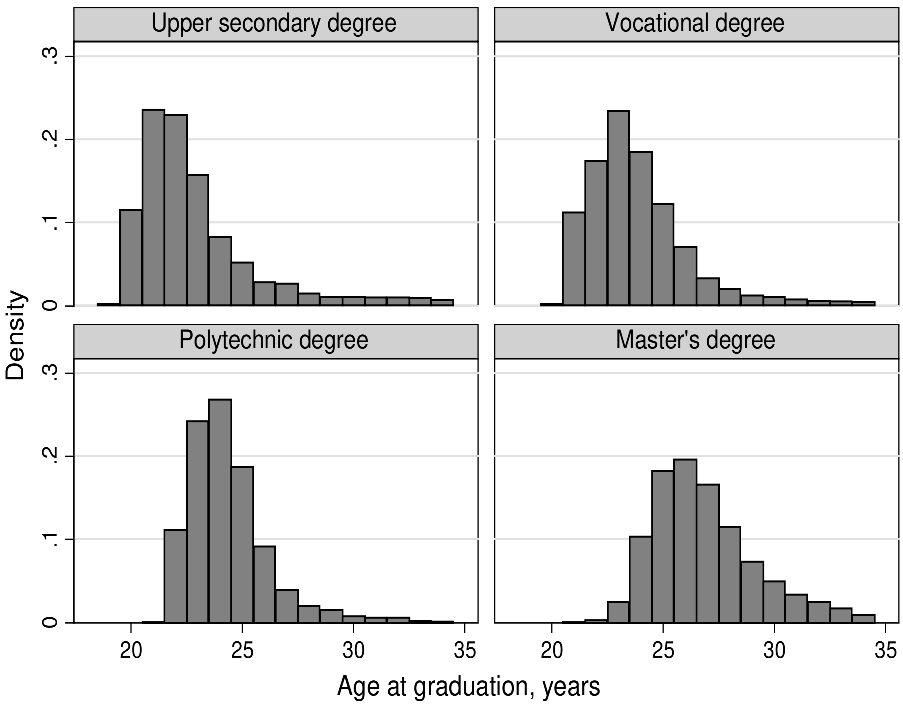

Figure W1. Histograms by the level of education: Age at the first graduation after high school (sample data).