Forthcoming in Spatial Economic Analysis
[Main Document and Supplementary Online Appendix]

More educated, more mobile? Evidence from post-secondary education reform*

Mika Haapanen†
University of Jyväskylä,
School of Business and Economics
Address: PO Box 35, FI-40014
Jyväskylä, Finland.
Tel. +358-41-4646375
E-mail: mika.p.haapanen@jyu.fi
Orcid: 0000-0003-2964-3352

Petri Böckerman
Turku School of Economics, Labour
Institute for Economic Research, and IZA
Address: Pitkänsillanranta 3 A,
FI-00530 Helsinki, Finland.
Tel. +358-9-25357360
E-mail: petri.bockerman@labour.fi

30 September 2016

Abstract

This paper examines the causal impact of the level of education on within-country migration. To account for biases resulting from selection into post-secondary education, we use a large-scale reform within the higher education system that gradually transformed former vocational colleges into polytechnics in Finland in the 1990s. This reform created quasi-exogenous variation in the supply of higher education over time and across regions. The results based on multinomial treatment effects models and population register data show that overall, polytechnic graduates have a significantly higher probability of migrating than vocational college graduates, although the estimates vary, for example, by gender, field of study, and region.

Keywords: migration; education; vocational colleges; polytechnics; reform

JEL classification: I21, R23

---

† Corresponding author

* We would like to thank Stefano DellaVigna, Paul J. Devereux, Kari Hämäläinen, Christopher Jepsen, Viktor Venhorst and seminar participants at the Regional Studies Association European Conference (Tampere, 2013), the Faculty of Economics, University College Dublin (2013), the XXX Summer Meeting of Finnish Economists (Jyväskylä, 2013) and the Labour Institute for Economic Research (Helsinki, 2013) for helpful comments. This study is supported by Yrjö Jahnsson Foundation (No. 6621) and Academy of Finland SRC projects “Work, Inequality and Public Policy” (No. 293120) and “Beyond MALPE coordination: integrative envisioning” (No. 303552).

1. Introduction

Education affects both the costs and the benefits of migration. Since the seminal contributions of Sjaastad (1962) and Bowles (1970), the relationship between education and within-country migration has been studied extensively. In recent years, greater emphasis has been placed on the identification of the causal effects of education on migration. The available evidence primarily concerns compulsory education.

The empirical studies of Machin, Salvanes, and Pelkonen (2012), McHenry (2013) and Weiss (2015) have used policy reforms to examine the effect of education on migration. These results are inconclusive. Using a Norwegian 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% from a low base rate of 1% per year. In contrast, McHenry (2013) reports that additional schooling at low education levels has a significant *negative* effect on migration in the U.S.; this study exploits variation in schooling due to compulsory schooling laws. Using individual-level data from eight European countries and educational reforms, Weiss (2015) finds that an additional year of compulsory education *increases* the number of regional migrations by 16% and the probability of moving to another region by 6% between the age of 15 and 50.

The causal evidence regarding post-secondary education and migration is even scarcer. Malamud and Wozniak (2012) use the variation in college attendance in the U.S. caused by draft-avoidance behavior during the Vietnam War. Their results imply that the additional years of college education significantly *increased* the likelihood that the affected men, later in life, resided outside the states where they had been born.

Contrary to most prior studies, which have analyzed the effects of additional years of schooling, the goal of this paper is to estimate the causal effect of the level of education on within-country migration. We use the post-secondary reform that took place in Finland in the 1990s. This reform gradually transformed former vocational colleges into polytechnics that offer bachelor's degrees. Therefore, we investigate whether the level of post-secondary vocational education has an effect on subsequent migration behavior. To account for biases resulting from selection into the different levels of education, we estimate multinomial treatment effects models with latent factors (Deb & Trivedi, 2006, 2009). Our analyses are based on comprehensive longitudinal register data for post-secondary graduates. The data allow us to use the number of new polytechnic study places in the home region of the graduates as an instrument for predicting the level of education. Using this novel research design, we find that obtaining a polytechnic degree instead of a vocational college degree causally increases the probability of migration. Our results also show considerable heterogeneity in the effects by gender, field of study, and graduation region.

Prior research has investigated the effect of the polytechnic reform on migration after high school in the Finnish setting. Using simple probit models and a seven percent random sample of high school graduates, Böckerman and Haapanen (2013) present reduced-form policy estimates based on the regional penetration of polytechnics over time. They find that the polytechnic reform increased the annual (school-to-school) migration rate of high school graduates by 1.2 percentage points over a three-year follow-up period. The current paper substantially deviates from Böckerman and Haapanen (2013) by presenting the general effects of the level of education on migration after graduation from post-secondary education. In contrast to previous research, we utilize newly assembled register data on the total population without conditioning on high school (HS) graduation and estimate multinomial treatment effects models that account for the endogeneity of the education choice. It is important not to condition the sample selection on the HS degree because approximately 20% of polytechnic graduates have not completed high school, and our results show substantial heterogeneity in the effect of polytechnic education by HS graduation.

The remainder of the paper is organized as follows. Section 2 discusses the theoretical arguments that link the level of education to migration. Section 3 describes the polytechnic education reform. Section 4 introduces the data. Section 5 describes the empirical modelling approach that allows for the endogeneity of education choice before migration. The results are reported in Section 6, and the final section concludes the paper.

2. Theoretical links between education and migration

The positive correlation between education and migration constitutes a well-known fact of the empirical literature. For example, Borjas's (2013, p. 321) labor economics textbook documents a higher migration rate between states of the U.S.A. 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).

Several theoretical explanations have been proposed for the positive relationship. Many of these are related to job search behavior. The first one is the existence of a greater earnings differential between regions for the highly educated; thus; greater potential benefits can be gained from moving (Armstrong & Taylor, 2000, p. 155). For example, Levy and Wadycki (1974) found that the highly educated are more responsive to wages in alternative locations. In related research, Wozniak (2010) has shown that the highly educated are also more responsive to local labor demand.

Second, education increases a person's capability of obtaining and analyzing 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 the job prospects and the living conditions in other regions.

Third, a higher level of educational attainment may open up new opportunities in the labor 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.

Fourth, the psychic costs resulting from the agony of departure from family and friends are likely to decrease with education (Schwartz, 1973).[1] Highly educated individuals differ little across regions in terms of their culture and manners. Therefore, they adapt more easily to new environments. Education may also reduce the importance of tradition and family ties and increase the individual's awareness of other locations and cultures. Greenwood (1975, p. 406) argues that the risk and uncertainty of migrating may be lower 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 personal networks (social ties) and improve labor market stability (e.g. smaller risk of unemployment, shorter unemployment spells and higher earnings); see e.g. Krabel and Flöther (2014). This increases the opportunity costs of

[1] Consistent with Schwartz (1973), Faggian and Franklin (2014) find for the U.S. that the distance required for a move is less of a deterrent for (college-bound) students with a higher quality of human capital than those with a lower quality of human capital.

moving and thus *reduces* the necessity to move to another region (McHenry, 2013, p. 38).[2]

The simultaneous 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 complete. *Ceteris paribus*, those with lower psychic costs of migration may invest more in their education because obtaining education frequently requires moving to a new region. That being said, unwillingness to move for work-related reasons may also result in extensive investment in education if an individual lives in a region with good educational opportunities.

For the reasons discussed above, educational attainment is almost always included in the set of variables used to explain a migration decision at the individual level (see e.g. Faggian, McCann, & Sheppard, 2007; Jaeger et al., 2010). Still, some authors maintain that education affects migration only through its impact on earnings (see Eliasson, Nakosteen, Westerlund, & Zimmer, 2014; Falaris, 1988, p. 527). Regardless of whether this assumption is correct, this indirect link provides another possible reason for the positive correlation between education and migration; the higher expected earnings enable individuals to cover the costs of migration more easily.

In contrast to Machin et al. (2012), Malamud and Wozniak (2012), McHenry (2013) and Weiss (2015), all other analyses use statistical models that treat education as exogenously determined. Education and migration decisions, however, are co-

[2] Prior literature has demonstrated that student migration is also related to the quality of educational institutions and local labor market conditions (Ciriaci, 2014; Dotti, Fratesi, Lenzi, & Percoco, 2013). Dotti et al. (2013) find that the attractiveness of the region for those who enrol in a university is linked to the prospects of job vacancies for graduates. Ciriaci (2014) highlights that students are not only attracted by high-quality universities but that the migration rates after graduation are also lower among graduates from high-quality universities than low-quality universities.

determined by unobserved factors such as personality traits (e.g. willingness to take risks and patience), parental values, and local personal networks. The endogeneity of the education decision is taken for 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. Although education is positively correlated with migration, it is unclear whether the significant correlation can be interpreted as a causal effect that is relevant for policy making. Additionally, the correlations in the total population do not provide evidence about the effect of education on migration in the upper part of education distribution. To provide policy-relevant evidence of the causal effect of education on within-country migration, we take advantage of a large-scale reform within the Finnish higher education system.

3. Higher education reform in Finland

Before the polytechnic education reform in the 1990s, post-secondary vocational education was divided into separate fields, each with its own schools. Schools were often small, and there was little co-operation between the fields of study. During the ten-year reform period, approximately 80% of the volume of education provided by the old post-secondary vocational colleges and schools were transformed into larger new polytechnics, while the remaining 20% continued to function in post-comprehensive vocational education (OECD, 2003, pp. 50–52); see Figure S1 in the Supplementary Appendix for a description of the Finnish education system before and after the reform.

Polytechnics provide high-level, non-academic vocational education (Lampinen, 2001). They offer bachelor-level degrees with a vocational emphasis that take from three and a half to four years to complete. The first 22 polytechnics were established under a temporary license in 1991. The network of polytechnics covered the entire country right from the start; that is, each NUTS-3 region had at least one polytechnic. The polytechnics were created by gradually merging 215 vocational colleges and vocational schools into new polytechnics. The gradual implementation of the reform implies that students who had started their studies before a vocational college transformed itself into a polytechnic continued their studies in the old college lines and that they eventually graduated with vocational college degrees. Seven new temporary licenses were granted during the 1990s. The trial period was judged to be successful by the Ministry of Education; since 1996, the polytechnics have gradually become permanent. There were 24 multidisciplinary polytechnics in 2014.

Vocational colleges were not simply relabeled as polytechnics (Lampinen, 2001; OECD, 2003; Välimaa & Neuvonen-Rauhala, 2008). The length of the studies increased, and according to a survey for teachers, program content become more demanding (Lampinen, 2001). The establishment and reinforcement of the polytechnics was financially supported by the Ministry of Education (OECD, 2003, p. 53). Additional resources were allocated to the polytechnics. Initial founding was mainly targeted at improving the qualifications of teachers and internationalization. Later, the support program was expanded (e.g. to library and information services). The polytechnics are very actively engaged in R&D, whereas the vocational colleges rarely engaged in R&D, apart from sporadic collaborations with local businesses (OECD, 2003, p. 119).

Earlier empirical studies have found economically significant effects from the creation of polytechnics that are consistent with the view that polytechnics offer improved vocational education versus the preceding vocational colleges. Hämäläinen and Uusitalo (2008) provide evidence for significant human capital effects from the polytechnic reform on earnings and explicitly reject the pure signaling hypothesis of education; see Böckerman, Hämäläinen, and Uusitalo (2009) for further evidence on the labor market returns to polytechnic education.

The supply of polytechnic education is controlled by the Ministry of Education through its decisions on the number of study places and school funding. The number of applications to the popular polytechnics exceeds the number of available places. The first graduates from the new polytechnics entered the labor market in 1994 (Figure 1). Until the end of the 1990s, the number of polytechnic degrees increased rapidly and vocational college degrees decreased correspondingly. By 2000, the number of new polytechnic degrees exceeded the number of university degrees, and by the early 2000s, only a few vocational college graduates were entering the labor market.

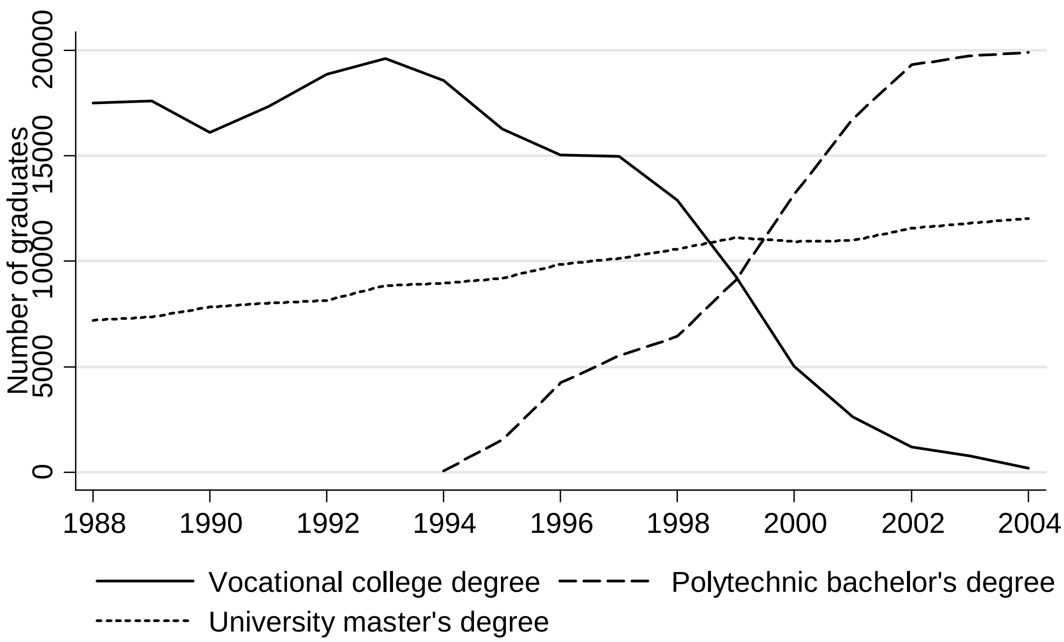


Figure 1. Vocational college, polytechnic and university graduates in Finland 1988–2004 (own calculations from population data).

4. Data

This study utilizes the newly assembled data on the total population of individuals under 70 years old in Finland over the period from 1988 to 2012. The data are constructed by Statistics Finland using the Longitudinal Population Census File, Longitudinal Employment Statistics File and Register of Completed Degrees. By matching the unique personal identifiers of individuals across the censuses, these panel data sets provide a variety of reliable, register-based information on the residents of Finland, including their partners, children, parents, and region of residence.

From these population data sets, we selected all those individuals who experienced their first graduation from post-secondary education (vocational college, polytechnic or university) between 1988 and 2004. The data were further restricted to graduating individuals under the age of 35 (without missing data). For each individual, we then recorded previous qualifications from secondary education; high school or vocational school degrees are required for entry into higher education. For 72% of the 360,212 graduates, their previous qualification was high school and for 28% of the graduates it was vocational secondary school.

In the analyses, we examine the long-distance migration between the 18 Finnish NUTS-3 regions, following Nivalainen (2004) and Haapanen and Tervo (2012); see the Supplementary Appendix, Table S1 for background information on the NUTS-3 regions, including a map. These migration flows allow us to examine the changes in the geographical distribution of human capital; the average distance of a move among the graduation-year migrants is 229 kilometers. Migrating shorter distances between municipalities or sub-regions most likely reflects the housing market conditions rather than the labor market prospects.

We study the migration after post-secondary education, which is defined as an indicator for moving between NUTS-3 regions during the graduation year or the following five years. Therefore, individuals are classified as migrants if they move at least once during the follow-up period. Approximately 34% of post-secondary graduates move during the six-year follow-up period. The key advantage of focusing on recent graduates is that we avoid the potential complications caused by the accumulation of firm-specific human capital on the turnover of workers (cf. Jovanovic, 1979).

Figure 2 illustrates the raw differences in the six-year migration rates according to the level of education.[3] The most important observation is that the new polytechnic graduates are more likely to move than the vocational college graduates before and after the reform. The migration rates between polytechnic and university graduates differ less. Both groups of graduates have experienced decreasing migration rates after 1997. Towards the end of the reform period, the migration gap between vocational college and polytechnic graduates narrows. This visual impression can be misleading in this respect, however, because there were only a few graduates from specialized vocational schools towards the end of the investigation period (cf. Figure 1). In estimation, we restrict the analyses to graduates from 1991–2001, so that they are from years close to the reform (including some years prior to the reform).

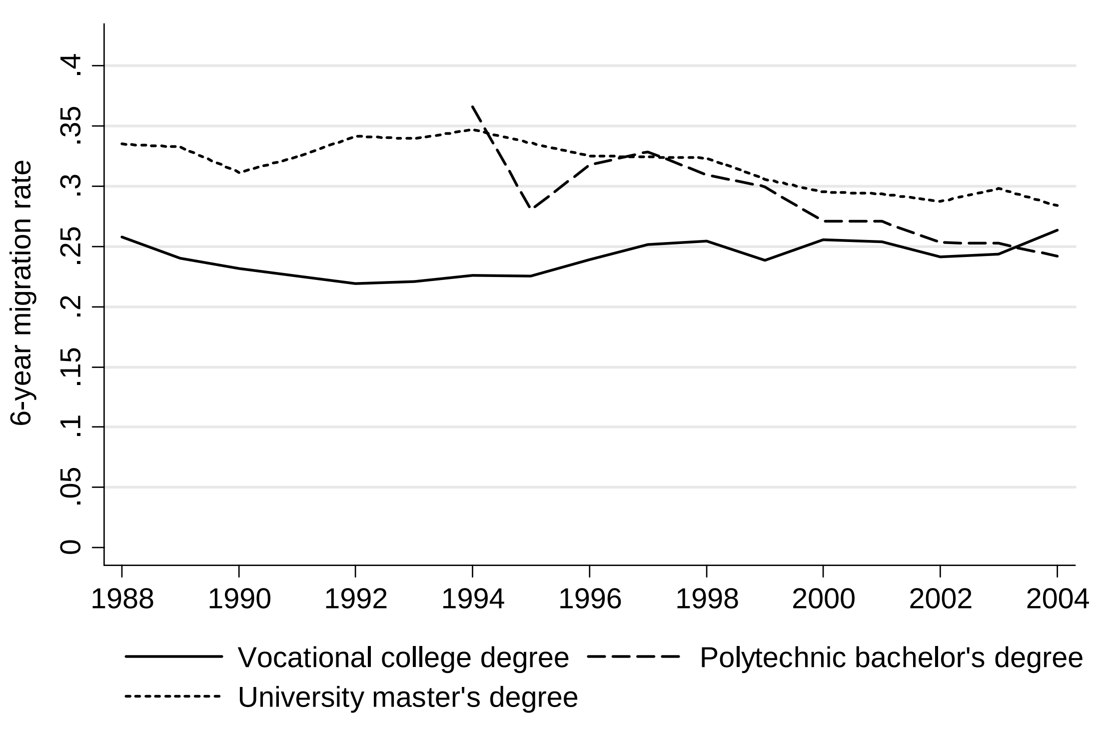


Figure 2. Six-year migration rates after graduation from the first post-secondary education (age less than 35 years).

[3] Note that the migration rates are computed as the total rates over the six-year follow-up period, instead of presented as annual averages over the six-year period.

5. Empirical specifications

5.1 Treating education as exogenous

Our purpose is to estimate the (causal) effect of the level of education on migration. We first assume that the individual's level of education is *exogenously* determined after the relevant controls have been added. Namely, we model the migration probability of an individual i using the standard binary logit model; that is, we assume that it is determined according to the logistic density function *f*.

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

where m_i is a binary dependent variable indicating whether (s)he migrates between the NUTS-3 regions during the six-year follow-up period. The vector $\mathbf{d}_i = [d_{i0}, d_{i1}, d_{i2}]$ represents an individual's choice among the three levels of post-secondary education d_{ij} : vocational college (j = 0; reference category), polytechnic (j = 1) or master's degree (j = 2). All the control variables, $\mathbf{x}_i$, are measured before an individual graduates from post-secondary education, so that the consequences of migration are not confused with the causes of migration. See Table S2 in the Supplementary Appendix for detailed definitions of the variables and their mean values.

Concerning personal characteristics, we control for age (including age squared to allow for non-linear effects), gender and whether an individual speaks Finnish as his/her first language (instead of Swedish or some other language). Böckerman and Haapanen (2013) have shown that the polytechnic reform increased migration after completion of *high school*. Because those who have moved in the past are more likely to move again (see e.g. DaVanzo, 1983), we control for the prior migration experience that occurred prior to completing a post-secondary education.

Individuals' prior scholastic achievement is controlled with dummies indicating whether an individual has ever graduated from high school and whether the previous qualification is from high school (instead of vocational school). Matriculation exam scores are available for those who have completed high school.[4] An individual's ability is expected to be positively correlated with migration, for example, because of greater potential monetary benefits from moving. The data also allow us to distinguish the effect of the education level from the field of education and to distinguish whether individuals live in the same region as their parents (an indicator of regional ties).

Regional labor market factors play an important role in explaining graduate migration (e.g. Krabel & Flöther, 2014; 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. Thus, these variables control, for example, for the size differences of regions (and the distance necessary for a migration event). Additionally, the number of 19 to 24-year-olds in the region of secondary education captures, for example, the possible yearly and regional differences in the demand for education. We also use the unemployment rate in the sub-region to account for the cyclical changes in the demand for education and labor. In sum, our first models are closely related to Figure 2, but they allow us to control for several individual-level factors along with the regional effects that influence migration decisions.

5.2 Accounting for the endogeneity of education

An obvious limitation of the migration model (1) is the assumption about the exogeneity of the choice of education. A causal interpretation of the results requires that an individual's potential migration outcomes are independent of the treatment conditional on the observed factors $\mathbf{x}_i$. This conditional independence assumption is unlikely to

[4] The matriculation examination is a national compulsory final exam taken by all students who graduate from high school. The answers for 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 standardized so that their distribution is the same every year.

hold even after using a rich set of controls. We chose to follow Deb and Trivedi (2006, 2009) and estimate a multinomial treatment effects model, which is particularly useful in our context because it generalizes a logit model by assuming the joint determination of the choice of education and the migration decision.

The education choice is modelled as *endogenous* by introducing unobserved latent characteristics (e.g. local networks and personality traits of individuals such as the attitudes toward risk that are not available even in the rich register-based data), $\mathbf{l}_i = [l_{i0}, l_{i1}, l_{i2}]$, that affect both the education choice and the migration decision. Conditional on the latent factors, an individual's choice among the three levels of post-secondary education, d_{ij} (*j*= 0, 1, 2), is modelled using the multinomial logit model:

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

where $\mathbf{x}_i$ denotes the vector of observed control variables (discussed above), z_i is the instrument, and δ_j's are the parameters associated with the latent factors l_{ij}. The binary migration decision is again modelled using a logistic density function *f*:

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

where the vector representing the education choice $\mathbf{d}_i$ is treated as endogenous.

Although this parametric model can technically be identified by its nonlinear functional form, it is recommend that an instrumental variable z_i be included in the education choice equation (2) but excluded from the migration equation (3) for a more robust identification (see Deb & Trivedi, 2006). A suitable instrument must satisfy two conditions. First, it must be strongly correlated with the level of education to avoid the weak instrument problem (Murray, 2006; Staiger & Stock, 1997). Second, the instrument must be exogenous; that is, it must be uncorrelated with the error term in the migration equation.

Our instrument for the level of education, z_i, is the supply of polytechnic education for an individual *i* when graduating from secondary education. It is measured as the number of new polytechnic study places in the individual's NUTS-3 region of residence. The relevance of the instrument is confirmed by the estimation results reported in Table 2 below. The instrument is evidently a strong predictor of the level of education ($p < 0.01$). The instrument is also a highly significant determinant of education choices across relevant sub-populations that we report later.

The validity of the instrument implies that it must be exogenously determined after controlling for other factors that potentially influence the migration decision. To address the potential concern related to the regional differences in the local demand for education, we use the number of 19 to 24-year-olds in the region as an additional control. To evaluate the exogeneity assumption, we utilize tests of overidentifying restrictions. Because there is no readily available test procedure for our nonlinear setting, we have also estimated linear instrumental variable (IV) models. Following Dieterle and Snell (2016), we use our instrument in the quadratic form to test for exogeneity (see also Cawley & Meyerhoefer, 2012). The intuition is that if the instrument z is mean independent of the error term, then both the instrument (z) and the instrument squared (z^2) should be valid instruments. Thus, if the test of the overidentifying restrictions fails to reject exogeneity in a model that uses z and z^2 as instruments, then neither is the validity of the instrument z rejected. In the most linear IV estimations, we restricted the sample to polytechnic and vocational graduates to facilitate our comparison of interest. Table S3 in the Supplementary Appendix presents the GMM estimation results of the linear IV models.[5] They show that both instruments

[5] Multinomial treatment effects models and the linear IV models produce qualitatively similar results.

are powerful and that the Hansen J-test does not reject the null hypothesis of the validity of the instruments (Columns 1 and 2 in Panels A and B). Reassuringly, exogeneity is not rejected in 14 of the 15 sub-sample analyses reported in Tables S4 and S5, either. The only exception is the sub-sample of graduates from the Uusimaa region. To conclude, our instrument is both powerful and valid.[6]

A key advantage of our parametric multinomial treatment effects model is that the inclusion of the common latent factors $\mathbf{l}_i$ in (2) and (3) helps to eliminate the endogeneity bias. These latent factors are not observed but their effects are integrated out of the joint probability function, for example, by taking 1,500 quasi-random draws based on Halton sequences from an independent standard normal distribution and using the maximum simulated likelihood. Finally, normalizations are required for the identification of the model (see Deb & Trivedi, 2006).

To calculate the marginal effects, we simulate discrete changes in the predicted migration probabilities by changing the educational attainment but keeping the same background characteristics, $\tilde{\mathbf{x}}$, fixed in the comparison. First we define $\tilde{\mathbf{x}}$ with the mean characteristics of all graduates over the period of 1991–2001 (Tables 1 and 2). Later we will use only the mean characteristics of the vocational college and polytechnic graduates (Table 3). Heteroskedasticity-robust standard errors that are clustered by graduation-region cells are reported.[7]

[6] We have also estimated logit migration models that included both the level of education dummies and our instrument. The coefficient for the instrument was close to zero (0.004) and highly insignificant (p = 0.619; providing additional support for exogeneity).

[7] We have also estimated standard errors using different assumptions (Huber-White robust and clustering on graduation-region-by-year cells), but we report the most conservative (i.e. the largest) standard errors.

6. Results

6.1 Education as exogenous

Table 1 reports the marginal effects of education on migration (exogenous education choice). Vocational college education is used as the reference group in all models, and the sample consists of graduates over the period from 1991 to 2001. 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 region by 7.2 percentage points. The effect of polytechnic education remains positive and statistically significant throughout as we load in controls from Column 2 onwards. The quantitative magnitude of the effect is the lowest once the full set of controls is used (Column 5). LR-ratio tests reveal that the addition of controls significantly improves the fit of the model. Thus, the estimates in Column 5 constitute the preferred model specification. They show that the marginal effect of polytechnic education on migration is 4.3 percentage points (16.0%; $p < 0.01$) from the base rate of 26.8%.

Table 1. Marginal effects of education on migration (exogenous education choice)

	(1)	(2)	(3)	(4)	(5)
Polytechnic degree	0.0716***	0.0565***	0.0552***	0.0568***	0.0429***
	(0.0147)	(0.0148)	(0.0143)	(0.0154)	(0.0113)
Master's degree	0.0919**	0.1331***	0.0777***	0.0762***	0.0851***
	(0.0407)	(0.0227)	(0.0231)	(0.0221)	(0.0121)
Regional effects[a]	no	yes	yes	yes	yes
Migration for studies	no	no	yes	yes	yes
Field of education	no	no	no	yes	yes
Other controls	no	no	no	no	yes
Log-likelihood	-149,046	-142,197	-135,700	-135,663	-130,483
LR-test over restricted specification	–	$p < 0.001$ (df = 15)	$p < 0.001$ (df = 1)	$p < 0.001$ (df = 3)	$p < 0.001$ (df = 10)

Notes: The number of observations is 233,839 in all logit models. Dependent variable: migration during the graduation year or the following five years. The reference is vocational college degree (average pred. probability conditional on voc. college is 0.268 in model 5). The marginal effects are calculated at the mean values of explanatory variables. The controls are defined in the Supplementary Appendix, Table S2. Heteroskedasticity-robust standard errors are reported in parentheses. df = degrees of freedom. [a] Includes graduation region dummies and regional unemployment rate. *** $p < 0.01$, ** $p < 0.05$.

6.2 Education as endogenous

Next, we estimate the equations for the education choice and migration jointly, as described in Section 5.2. The first two columns of Table 2 report the estimation results for the education choice equations while treating vocational college education as the reference group. In this endogenous education choice model we use the supply of polytechnic education in the region where an individual graduated from secondary education as an instrument for her or his level of education. Therefore, the variable is included in the education choice equations but it is excluded from the migration equation (third column). The results show that the supply of polytechnic education in the secondary education region considerably increases the probability of graduating from a polytechnic ($p < 0.01$) and to a smaller extent, the probability of graduating from a university ($p < 0.01$). The two coefficients of the instrument are different from zero, which confirms that the instrument has substantial predictive power and is thus relevant.

The results for education choice also reveal other interesting patterns. For example, we observe that a person's completed level of education increases with the high school matriculation exam score. Thus, those who have better (measured) ability tend to obtain a significantly higher level of formal education when all other things are equal. The parameter estimate of the compulsory matriculation exam score is particularly high for completing a master's degree.

Table 2. Estimates from the multinomial treatment effects model (endogenous education choice)

	Education choice		Migration
	Polyt. degree	Master's degree	Choice
Polytechnic degree			0.4188***
			(0.1507)
Master's degree			0.3579**
			(0.1486)
Migrated for studies	0.0903	0.8137***	0.4373***
	(0.1252)	(0.1071)	(0.0419)
Technology	1.2262***	1.1010**	-0.0551
	(0.2245)	(0.4793)	(0.0796)
Health care	0.3547	-1.3570***	0.1355
	(0.2703)	(0.3951)	(0.1008)
Other fields of education	-0.5847*	1.3290***	0.1658*
	(0.3145)	(0.3188)	(0.0943)
Age	2.8701***	6.2649***	0.2282***
	(0.1368)	(0.1187)	(0.0472)
Age squared	-5.0573***	-10.6924***	-0.6340***
	(0.2580)	(0.2078)	(0.0943)
Female	0.1538***	-0.2025**	-0.1896***
	(0.0548)	(0.0946)	(0.0316)
Finnish	0.2120	-0.7539***	0.4053***
	(0.1965)	(0.1883)	(0.1491)
Ever matriculated	-0.4375***	-3.4240***	-0.1085
	(0.0905)	(0.4245)	(0.0661)
Previous degree high school	0.9381***	3.0221***	0.0334
	(0.0674)	(0.0985)	(0.0227)
Matricul. Result	0.2971***	1.6736***	0.0641***
	(0.0225)	(0.0644)	(0.0144)
Parents' location	0.0894*	-0.2248***	-0.7127***
	(0.0468)	(0.0552)	(0.0688)
19–24-year-olds	-0.2000***	-0.0079	-0.1008***
	(0.0542)	(0.0210)	(0.0061)
Unemployment rate	-1.1059	-0.9332*	1.3146***
	(2.4283)	(0.5575)	(0.3147)
Supply of polyt. Education	1.7693***	0.5377***	
	(0.4829)	(0.1039)	
λ (Polytechnic degree)			-0.2897*
			(0.1515)
λ (Master's degree)			0.1075
			(0.1584)
Regional dummies	yes	yes	Yes

Notes: The number of observations is 233,839. The log-likelihood is -251,471. LR-test for no unobserved heterogeneity: $p < 0.001$. The marginal effect of a polytechnic degree is 0.0883*** and a master's degree is 0.0746** (at the mean values of explanatory variables). The results are based on the joint estimation of choice between the three levels of education (ref. is vocational college degree) and moving during the graduation year or the following five years. The choice-specific constants and the dummy for missing matriculation exam score are not reported for brevity. See Supplementary Appendix, Table S2 for the definitions of variables. Heteroskedasticity-robust standard errors are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

The LR-ratio test results indicate the importance of controlling for the unobserved heterogeneity: the exogenous models are clearly rejected in favor of the endogenous models with the latent factors (p-values < 0.001). A negative coefficient of the latent factor for selection into polytechnic education points to the existence of unobserved heterogeneity in the model ($p < 0.10$); see the third column of Table 2. On the contrary, we do not find selection into university education (compared to vocational degrees) based on unobservables after controlling for differences in several background characteristics (including quality). The estimated coefficient (λ) is small and insignificant. Because the estimated λ is small in size, the estimated marginal effect of a master's degree is similar in the exogenous and endogenous models.

Hence, there are significant unobserved traits that are important for both migration and selection into polytechnic education. The negative latent factor suggests that there are unobserved traits that correlate positively (negatively) with the likelihood of obtaining a polytechnic degree and correlate negatively (positively) with migration intensity. Although it is often assumed that latent factors correlate in the same direction with education and migration, recent literature on education and migration has highlighted the possibility that (unobserved) local personal networks may predict more education and less migration (see McHenry, 2013). For example, the polytechnic study place may increase the strength of local job network ties and provide employment stability in the local area (e.g. due to the positive signaling effect on ability). This raises the opportunity costs of migration and reduces geographic mobility.

In the third column that reports the determinants of migration, the coefficient for a polytechnic degree is positive and statistically significant ($p < 0.01$). Note, however, that the selection effects have a considerable impact on the quantitative magnitude of the estimated coefficient on the polytechnic degree when the joint estimator is applied (see also Table 3 below). After accounting for the endogeneity of the education choice, the marginal effect is significantly larger than in the logit models that assume strict exogeneity. This is a natural implication from the estimated negative λ's on a polytechnic degree. Previous migration studies have also found the IV estimates to be larger than those assuming exogenous schooling choice (see Machin et al., 2012; Malamud & Wozniak, 2012; Weiss, 2015).[8] In fact, after controlling for the unobserved heterogeneity, the effect of education is estimated to be similar between polytechnic and university graduates.

Reassuringly, the estimated impacts of the exogenous covariates in the migration equation (column 3 of Table 2) are also in accordance with the prior literature. For example, the matriculation exam score from high school is strongly positively related to migration. This result implies that graduates with better (measured) ability are more likely to migrate, which is even conditional on completed formal education. As the exam score also positively affects the likelihood of completing higher education (columns 1 and 2), this result also highlights the importance of controlling for this ability when studying the effect of education on migration.

Table 3 displays the heterogeneity of the treatment effect of polytechnic vs. vocational college education on migration. The reported marginal effects are calculated using only the characteristics of the vocational college and polytechnic graduates. Calculated from the full data, the quantitative magnitude of the polytechnic education on migration is the same as before (0.088; $p < 0.01$); the baseline rate is 26.8% for the vocational college-educated individuals.

[8] For example, Weiss's (2015) IV estimates of ever moving to another region are 2–3 times as large as the OLS estimates.

Table 3. Marginal effects of polytechnic education on migration: Heterogeneity

	Number of observations	Exogenous educ. choice		Endogenous educ. choice		
All individuals						
Mean	233,839	0.0429***	(0.0112)	0.0878***	(0.0317)	
Gender						
Male	92,150	0.0550***	(0.0120)	0.0987***	(0.0275)	
Female	141,689	0.0340***	(0.0118)	0.0655*	(0.0347)	
Matriculated						
Yes	194,287	0.0373***	(0.0114)	0.0914***	(0.0313)	
No	39,552	0.0716***	(0.0141)	0.1396**	(0.0565)	
Field of study						
Business	73,623	0.0488***	(0.0142)	0.0707***	(0.0129)	
Technology	46,364	0.0835***	(0.0150)	0.0782***	(0.0280)	†
Health	47,914	0.0127	(0.0105)	0.0280**	(0.0118)	†
Graduation region						
Uusimaa	65,447	-0.0140***	(0.0041)	-0.0289***	(0.0097)	
Other regions	168,392	0.0588***	(0.0080)	0.1190***	(0.0216)	

Notes: The marginal effects have been calculated using only the mean characteristics of the vocational college and polytechnic graduates. The specifications for these sub-sample estimations are the same as in Table 2. Heteroskedasticity-robust standard errors are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. † LR-test does not reject the exogenous model ($p > 0.1$). In all other cases, the exogenous model is rejected.

Table 3, however, reveals considerable heterogeneity in the effects across sub-samples.[9] Polytechnic education increases migration more for males than females and less for the matriculated (i.e. high school graduates) than not matriculated. Thus, our results for Finland show that females not only have lower migration rates than males,[10] but the effect of polytechnic education on migration is also lower for women. Additionally, Machin et al. (2012) found a lower (but imprecise) effect of (compulsory) education on migration for women than for men. The estimated effect of polytechnic education on migration is considerably larger for Finnish graduates in technology (typically engineers) and business fields than in health care fields. These results are

[9] As reported in the Supplementary Appendix, Table S4, the results are qualitatively similar when we estimate the models with linear IV instead of using the preferred multinomial treatment effect model.

[10] This is contrary to the findings for the U.K. university graduates, where female graduates are generally more geographically mobile than male graduates (Faggian, McCann, & Sheppard, 2007).

consistent with Venhorst et al. (2010), who show that the Dutch college graduates of engineering and economics fields are more likely to move from the peripheral regions to the economic center of the country than college graduates of health care fields.

To obtain a complete picture, we have also investigated possible gender differences on the effect of polytechnic education within each field. The results reported in the Supplementary Appendix (Table S5) do not reveal large gender differences, but they do provide some evidence that the positive effect of polytechnic education on migration is larger for male technology field graduates than female technology field graduates; the reverse prevails for business and health care field graduates. Thus, the reason for the smaller estimated effect of polytechnic education on migration for women than for men is mainly explained by two patterns: i) women are more likely to graduate from health care fields and less likely to graduate from technology fields than men; ii) regardless of gender, the estimated effect of polytechnic education on migration is smaller in health care fields than in technology fields. To conclude, the differences between the fields of education are of greater importance than the differences between genders within fields.

Interestingly, the results show that in the capital region, Uusimaa, the polytechnic graduates have *lower* migration rates that the corresponding vocational college graduates.[11] The result is consistent with the view that the local demand for highly educated people is particularly high in the Uusimaa region. Because the local labor markets are much thicker in Uusimaa compared to other regions, it is easy for graduates in Uusimaa to find a job without migrating to other regions. In sum, the positive effects of higher education are driven by increased migration rates outside of Uusimaa.

[11] The estimate for Uusimaa should be interpreted with some caution because the Hansen J-test rejects the null hypothesis of the validity of the instrument for this specific sub-sample.

6.3 Additional analyses

We have also estimated the effect of polytechnic education on migration using alternative instrumental variables, alternative sub-samples and alternative specifications of the dependent variable. These results are reported in the Supplementary Appendix. We describe the results only briefly. When we utilize our instrument in quadratic form, the results remain qualitatively unchanged (Table S3). The estimated effects of polytechnic education are again positive and significant. Accounting for the endogeneity of the education decision remains important, i.e., unobserved latent factors are jointly significant in all models ($p < 0.01$).

A frequently used instrument for a person's educational attainment is her/his parent's education (see e.g. Lemke & 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 (see note to Table S3). Again, the stability of the estimated effects is encouraging. That being said, the use of parental education as an instrument has been criticized by Card (1999, p. 1822-1826) on the grounds that parental education often directly affects the offspring's labor market outcomes, such as earnings, or is at least correlated with the error term.

We have also altered the definition of migration. In the Supplementary Appendix, we report the results for migration between 79 NUTS-4 (i.e., LAU-1) sub-regions, instead of the NUTS-3 regions, and for longer-distance migration between the four NUTS-2 regions (Table S6). The estimated marginal effects are similar in absolute size regardless of the regional classification. Note, however, that the effect of polytechnic education on migration is lower in percentages at small spatial scales (NUTS-4) than at large spatial scales (NUTS-2) because the base migration rates are higher in the former case (39%) than in the latter case (27%). Additional analyses show that polytechnic education also significantly decreases the likelihood of living in the post-secondary graduation region and of living in the secondary education region after the six-year follow-up period (i.e., additional education makes graduates more mobile). Overall, the effects of polytechnic education on migration are all significant at the 1% level.

Furthermore, the effect of education on the graduate migration may differ by prior mobility. Therefore, we have also conducted the analysis separately for individuals who have moved for their post-secondary education (movers), and for individuals who did not move (stayers); see Table S6 in the Supplementary Appendix. For the latter group of graduates (i.e., stayers), we find a clear positive effect of polytechnic education on migration: the estimated marginal effect is 0.067 ($p < 0.01$). For the school-to-school movers, we have estimated the changes in the probability of onward migration (i.e., migrating to some other region than their secondary education region) and return migration (i.e., migrating to their secondary education region). Our results suggest that polytechnic education (when compared to vocational college education) substantially increases the probability of returning to the region of origin and decreases (unexpectedly) the probability of onward migration to some extent.

One of the main limitations in our endogenous models is that they rest on the parametric normality assumptions of the latent variables. For this reason, we have also estimated linear instrumental variable (IV) models using GMM. First, we exclude graduates with master's degree and keep only vocational college and polytechnic graduates in the estimating sample. Reassuringly, this IV estimate (0.048; $p < 0.01$) falls between the exogenous and endogenous model results (Table S3). Second, we have also utilized the linear IV models and measured education with a nominal amount of years in education (instead of discrete levels). In this modelling framework, one additional year of education increases the propensity to move over the six-year period by 3.7 percentage points. Note, however, that this model assumes the same change in migration probability from an additional year of schooling at all levels of education.

The second limitation of our endogenous model is that it does not allow us to use graduation-year dummies. If there is a positive trend in the migration rates of polytechnic graduates or a negative trend in the migration rates of vocational graduates over time (not captured by our controls), then our estimates would be biased upwards. A visual inspection of Figure 2, however, suggests the opposite: our estimates should be downward biased, suggesting that the baseline point estimates are conservative. Similarly, the addition of year dummies to the preferred logit model reported in Table 1 increases, not decreases, the estimated effects of polytechnic education on migration (marginal effect is approximately 0.06).[12] To further evaluate the importance of time effects, we have also estimated the endogenous treatment models for each polytechnic graduate cohort (1995–2001) in such a way that graduates from other levels within the previous five years constitute the comparison groups. For example, polytechnic graduates from 2000 are compared with other graduates from 1996 to 2000. This five-year window improves the identification of the model. The results reported in Table S7 in the Supplementary Appendix suggest that the effect of polytechnic education on migration were greatest for the first graduate cohorts, and this effect has decreased over time (0.065 in 2001; $p < 0.01$). This finding is consistent with the descriptive results (Figure 2).

7. Conclusions

The positive relationship between education and migration is taken for granted in much of the literature, but the empirical evidence that there is a causal effect of education on

[12] We have also conducted several additional analyses that are reported in the Supplementary Appendix (see Tables S8–S10). For example, our results are robust to the inclusion of additional variables to the set of controls (e.g., a person's own earnings or family characteristics and the region of secondary education).

within-country migration is limited. Only recently has economic research addressed this issue (Machin et al., 2012; Malamud & Wozniak, 2012; McHenry, 2013; Weiss, 2015). The existing causal estimates are inconclusive and the effects in the upper part of the education distribution have received scant attention in the research literature.

In this paper, we examined the effects of education on within-country migration using comprehensive longitudinal register data. A large-scale higher education reform took place in Finland in the 1990s. This quasi-exogenous reform gradually transformed vocational colleges into polytechnics. We exploited the reform to study the causal effect of education on the migration of the young adults who had graduated from post-secondary education.

Consistent with Malamud and Wozniak (2012), our estimation results show that the polytechnic graduates have higher a probability of migrating during a six-year follow-up period than the vocational college graduates. Thus, our findings reveal that the introduction of the polytechnics not only increased migration after high school (Böckerman & Haapanen, 2013) but also affected mobility after post-secondary education, which is more relevant for the relocation of educated workers across regions. That being said, we find that the effect of polytechnic education on migration is greater for men than for women, and overall, the effect was positive except for the Uusimaa (capital) region, where the demand for this type of labor is relatively weaker.

We have shown that higher education has a positive effect on migration. Further research is needed to quantify the extent to which increased migration can explain the positive effects of polytechnic education on earnings and employment (Böckerman et al., 2009; Hämäläinen & Uusitalo, 2008). More broadly, our identification strategy can also be utilized to study how education affects other outcomes. For example, future research could estimate the long-run effects of higher vocational education on non-pecuniary outcomes, such as health and satisfaction (see Cutler & Lleras-Muney, 2008;

Grossman, 2015; Oreopoulos & Salvanes, 2011 for prior evidence). It would also be interesting to examine whether migration mediates the effects of education on these non-pecuniary outcomes.

References

Armstrong, M., & Taylor, J. (2000). *Regional economics and policy* (3rd ed.). Oxford: Wiley-Blackwell.

Böckerman, P., & Haapanen, M. (2013). The effect of polytechnic reform on migration. *Journal of Population Economics*, *26*(2), 593–617. https://doi.org/10.1007/s00148-012-0454-4

Böckerman, P., Hämäläinen, U., & Uusitalo, R. (2009). Labour market effects of the polytechnic education reform: The Finnish experience. *Economics of Education Review*, *28*(6), 672–681. https://doi.org/10.1016/j.econedurev.2009.02.004

Borjas, G. J. (2013). *Labor economics* (6th ed.). New York: McGraw-Hill.

Bowles, S. (1970). Migration as investment: empirical tests of the human investment approach to geographical mobility. *The Review of Economics and Statistics*, *52*(4), 356–362. https://doi.org/10.2307/1926312

Card, D. (1999). The causal effect of education on earnings (Chapter 30). In O. C. Ashenfelter & D. Card (Eds.), *Handbook of Labor Economics* (Vol. 3, Part A, pp. 1801 – 1863). Amsterdam: Elsevier. Retrieved from http://www.sciencedirect.com/science/article/pii/S1573446399030114

Cawley, J., & Meyerhoefer, C. (2012). The medical care costs of obesity: An instrumental variables approach. *Journal of Health Economics*, *31*(1), 219–230. https://doi.org/10.1016/j.jhealeco.2011.10.003

Ciriaci, D. (2014). Does university quality influence the interregional mobility of students and graduates? The case of Italy. *Regional Studies*, *48*(10), 1592–1608. https://doi.org/10.1080/00343404.2013.821569

Cutler, D., & Lleras-Muney, A. (2008). Education and health: Evaluating theories and evidence. In J. House, R. Schoeni, G. Kaplan, & H. Pollack (Eds.), *Making Americans Healthier: Social and Economic Policy as Health Policy*. New York: Russell Sage Foundation. Retrieved from https://www.russellsage.org/publications/books/080117.779084

DaVanzo, J. (1983). Repeat migration in the United States: Who moves back and who moves on? *The Review of Economics and Statistics*, *65*(4), 552–559. https://doi.org/10.2307/1935923

Deb, P., & Trivedi, P. K. (2006). Specification and simulated likelihood estimation of a non-normal treatment-outcome model with selection: Application to health care utilization. *Econometrics Journal*, *9*(2), 307–331. https://doi.org/10.1111/j.1368-423X.2006.00187.x

Deb, P., & Trivedi, P. K. (2009). Provider networks and primary-care signups: Do they restrict the use of medical services? *Health Economics*, *18*(12), 1361–1380. https://doi.org/10.1002/hec.1432

Dieterle, S. G., & Snell, A. (2016). A simple diagnostic to investigate instrument validity and heterogeneous effects when using a single instrument. *Labour Economics*, *42*, 76–86. https://doi.org/10.1016/j.labeco.2016.08.002

Dotti, N. F., Fratesi, U., Lenzi, C., & Percoco, M. (2013). Local labour markets and the interregional mobility of Italian university students. *Spatial Economic Analysis*, *8*(4), 443–468. https://doi.org/10.1080/17421772.2013.833342

Ehrenberg, R. G., & Smith, R. S. (2009). *Modern labor economics: Theory and public policy*. Boston: Pearson/Addison Wesley.

Eliasson, K., Nakosteen, R., Westerlund, O., & Zimmer, M. (2014). All in the family: Self-selection and migration by couples. *Papers in Regional Science, 93*(1), 101–124. https://doi.org/10.1111/j.1435-5957.2012.00473.x

Faggian, A., & Franklin, R. S. (2014). Human capital redistribution in the USA: the migration of the college-bound. *Spatial Economic Analysis*, *9*(4), 376–395. https://doi.org/10.1080/17421772.2014.961536

Faggian, A., McCann, P., & Sheppard, S. (2007). Human capital, higher education and graduate migration: An analysis of Scottish and Welsh students. *Urban Studies, 44*(13), 2511–2528. https://doi.org/10.1080/00420980701667177

Falaris, E. M. (1988). Migration and wages of young men. *The Journal of Human Resources*, *23*(4), 514–534. https://doi.org/10.2307/145811

Greenwood, M. J. (1975). Research on internal migration in the United States: A survey. *Journal of Economic Literature*, *13*(2), 397–433. https://doi.org/10.2307/2722115

Greenwood, M. J. (1997). Internal migration in developed countries (Chapter 12). In M. R. Rosenzweig & O. Stark (Eds.), *Handbook of population and family economics* (Vol. 1, Part B, pp. 647 – 720). Elsevier. Retrieved from http://www.sciencedirect.com/science/article/pii/S1574003X97800049

Grossman, M. (2015). *The relationship between health and schooling: What's new?* (Working Paper No. 21609). National Bureau of Economic Research. Retrieved from http://www.nber.org/papers/w21609

Haapanen, M., & Tervo, H. (2012). Migration of the highly educated: Evidence from residence spells of university graduates. *Journal of Regional Science*, *52*(4), 587–605. https://doi.org/10.1111/j.1467-9787.2011.00745.x

Hämäläinen, U., & Uusitalo, R. (2008). Signalling or human capital: Evidence from the Finnish polytechnic school reform. *Scandinavian Journal of Economics*, *110*(4), 755–775. https://doi.org/10.1111/j.1467-9442.2008.00560.x

Jaeger, D. A., Dohmen, T., Falk, A., Huffman, D., Sunde, U., & Bonin, H. (2010). Direct evidence on risk attitudes and migration. *Review of Economics and Statistics*, *92*(3), 684–689. https://doi.org/10.1162/REST_a_00020

Jovanovic, B. (1979). Job matching and the theory of turnover. *Journal of Political Economy*, *87*(5), 972–990. https://doi.org/10.2307/1833078

Krabel, S., & Flöther, C. (2014). Here today, gone tomorrow? Regional labour mobility of German university graduates. *Regional Studies*, *48*(10), 1609–1627. https://doi.org/10.1080/00343404.2012.739282

Lampinen, O. (2001). The use of experimentation in educational reform: The case of the Finnish polytechnic experiment 1992–1999. *Tertiary Education and Management*, *7*(4), 311–321. https://doi.org/10.1023/A:1012710220796

Lemke, R. J., & Rischall, I. C. (2003). Skill, parental income, and IV estimation of the returns to schooling. *Applied Economics Letters*, *10*(5), 281–286. https://doi.org/10.1080/1350485032000078653

Levy, M. B., & Wadycki, W. J. (1974). Education and the decision to migrate: An econometric analysis of migration in Venezuela. *Econometrica*, *42*(2), 377–388. https://doi.org/10.2307/1911985

Machin, S., Salvanes, K. G., & Pelkonen, P. (2012). Education and mobility. *Journal of the European Economic Association*, *10*(2), 417–450. https://doi.org/10.1111/j.1542-4774.2011.01048.x

Malamud, O., & Wozniak, A. (2012). The impact of college on migration: Evidence from the Vietnam generation. *Journal of Human Resources*, *47*(4), 913–950.

McCormick, B. (1997). Regional unemployment and labour mobility in the UK. *European Economic Review*, *41*(3–5), 581–589. https://doi.org/10.1016/S0014-2921(97)00024-X

McHenry, P. (2013). The relationship between schooling and migration: Evidence from compulsory schooling laws. *Economics of Education Review*, *35*, 24–40. https://doi.org/10.1016/j.econedurev.2013.03.003

Murray, M. P. (2006). Avoiding invalid instruments and coping with weak instruments. *Journal of Economic Perspectives*, *20*(4), 111–132. https://doi.org/10.1257/jep.20.4.111

Nivalainen, S. (2004). Determinants of family migration: Short moves vs. long moves. *Journal of Population Economics*, *17*(1), 157–175. https://doi.org/10.1007/s00148-003-0131-8

OECD. (2003). *Polytechnic Education in Finland*. Paris: OECD.

Oreopoulos, P., & Salvanes, K. G. (2011). Priceless: The nonpecuniary benefits of schooling. *The Journal of Economic Perspectives*, *25*(1), 159–184. https://doi.org/10.2307/23049443

Schwartz, A. (1973). Interpreting the effect of distance on migration. *Journal of Political Economy*, *81*(5), 1153–1169. https://doi.org/10.2307/1830643

Sjaastad, L. A. (1962). The costs and returns of human migration. *Journal of Political Economy*, *70*(5), 80–93. https://doi.org/10.2307/1829105

Staiger, D., & Stock, J. H. (1997). Instrumental variables regression with weak instruments. *Econometrica*, *65*(3), 557–586. https://doi.org/10.2307/2171753

Välimaa, J., & Neuvonen-Rauhala, M.-L. (2008). Polytechnics in Finnish higher education. In J. S. Taylor, J. B. Ferreira, M. de L. Machado, & R. Santiago (Eds.), *Non-University Higher Education in Europe* (pp. 77–98). Springer

Netherlands. Retrieved from http://link.springer.com/chapter/10.1007/978-1-4020-8335-8_4

Venhorst, V., Van Dijk, J., & Van Wissen, L. (2010). Do the best graduates leave the peripheral areas of the Netherlands? *Tijdschrift Voor Economische En Sociale Geografie*, *101*(5), 521–537. https://doi.org/10.1111/j.1467-9663.2010.00629.x

Venhorst, V., Van Dijk, J., & Van Wissen, L. (2011). An analysis of trends in spatial mobility of Dutch graduates. *Spatial Economic Analysis*, *6*(1), 57–82. https://doi.org/10.1080/17421772.2010.540033

Weiss, C. T. (2015). Education and regional mobility in Europe. *Economics of Education Review*, *49*, 129–141. https://doi.org/10.1016/j.econedurev.2015.09.003

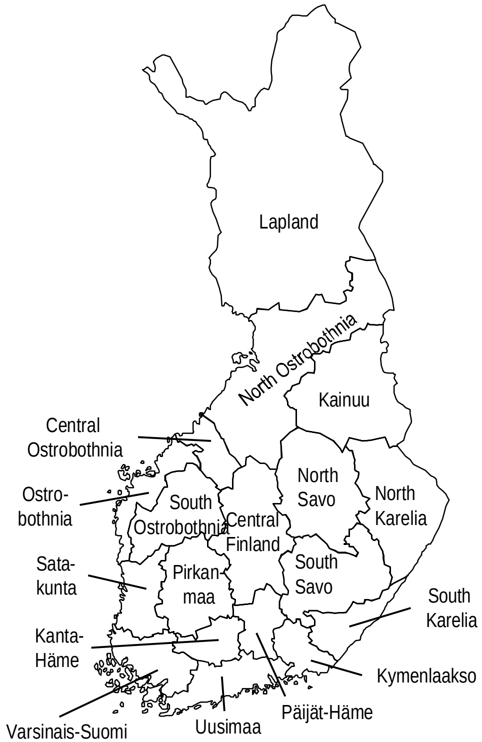
Wozniak, A. (2010). Are college graduates more responsive to distant labor market opportunities? *Journal of Human Resources*, *45*(4), 944–970.

Additional material for the paper “More educated, more mobile? Evidence from post-secondary education reform” (not to be published in the printed article).

Content

Table S1. Background information on the NUTS-3 regions in Finland (2000)

NUTS-3 region	Population	Land area (km^2)	Population density (per km^2)	Average household disposable income (euro per person)	Unemployment rate (%)	Number of polytechnics	Map of the NUTS-3 regions
Uusimaa	1,394,199	9,132	152.7	24,462	6.3	8	
Varsinais-Suomi	447,103	10,666	41.9	19,645	8.0	1	
Satakunta	232,569	7,818	29.8	18,357	10.9	1	
Kanta-Häme	165,307	5,199	31.8	18,839	8.5	1	
Pirkanmaa	450,346	12,328	36.5	19,402	10.4	2	
Päijät-Häme	197,378	5,127	38.5	18,509	11.9	1	
Kymenlaakso	187,474	5,112	36.7	18,810	12.2	1	
South Karelia	136,299	5,329	25.6	18,644	10.3	1	
South Savo	166,575	14,284	11.7	17,523	13.8	1	
North Savo	253,759	16,772	15.1	17,844	11.8	1	
North Karelia	171,609	17,763	9.7	17,109	15.1	1	
Central Finland	265,683	16,965	15.7	18,193	12.0	1	
South Ostrobothnia	195,615	13,445	14.6	17,934	10.4	1	
Ostrobothnia	173,228	7,748	22.4	19,271	8.0	2	
Central Ostrobothnia	68,052	5,018	13.6	17,914	11.6	1	
North Ostrobothnia	368,598	35,488	10.4	19,076	11.7	1	
Kainuu	89,777	21,506	4.2	17,186	19.4	1	
Lapland	191,768	92,856	2.1	17,605	17.6	2	



Notes: All information are from 2000 and they have are obtained from Statistics Finland.

Table S2. Description of covariates and their mean values

	Description	Mean
Dependent variable		
Migration	1 if person migrates between NUTS-3 regions during the post-secondary graduation year or the following five years, 0 otherwise	0.3408
Level of education		
Vocational college degree	1 if post-secondary degree is vocational college, 0 otherwise (reference category)	0.4884
Polytechnic degree	1 if post-secondary degree is polytechnic, 0 otherwise	0.1649
Master's degree	1 if post-secondary degree is master's, 0 otherwise	0.3467
Instrument		
Supply of polytechnic education	Number of first-year polytechnic students in the NUTS-3 region where the previous secondary education was completed (1,000 students)	0.3579
Control variables		
Graduation region	Regional dummies (18) indicate the NUTS-3 region where the post-secondary education was completed	–
Migrated for studies	1 if post-secondary degree region differs from the secondary degree region; 0 otherwise	0.4807
Business	1 if the field of education is business, administration, and social sciences; 0 otherwise (reference category)	0.3148
Technology	1 if the field is technology or transport; 0 otherwise	0.1983
Health care	1 if the field is health care or welfare; 0 otherwise	0.2049
Other fields	1 if the field is something else; 0 otherwise	0.2820
Age	Age in years	24.788
Age squared	Age/10 squared	6.2515
Female	1 if female, 0 if male	0.6059
Finnish	1 if first language is Finnish, 0 otherwise	0.9492
Ever matriculated	1 if has ever graduated from high school, 0 otherwise	0.8309
Previous degree high school	1 if graduated from high school only before post-secondary education; 0 otherwise	0.7087
Matricul. result	General grade from matriculation exam conducted at the end of high school. Range from 1 (lowest grade) to 6 (highest grade). 0 if missing or not matriculated.	3.6262
Matr. result missing	1 if exam result is missing or not matriculated, 0 otherwise	0.0286
Parents' location	1 if post-secondary graduation from a NUTS-3 region where either of the parents lived; 0 otherwise	0.4992
19–24-year-olds	19 to 24-year-olds in the region of the secondary education (1,000 individuals)	3.8656
Unemployment rate	Unemployment rate in the NUTS-4 (LAU-1) region (i.e. travel-to-work area), %	0.1586
Number of observations		233,839

Notes: The control variables are measured on a year before an individual graduates from the first post-secondary education if not otherwise stated. Sample includes graduates from 1991–2001. The individuals from the Åland Islands are not included in the data.

Table S3. The effect of polytechnic education on six-year migration: robustness of the results to the method

	(1) Baseline model	(2) Quadratic instrument†	(3) Graduation year trend control added
Panel A: Multinomial treatment effect model: marginal effects (N = 233,839)			
Polytechnic vs. vocational education	0.0878***	0.0675***	0.1611***
	(0.0317)	(0.0079)	(0.0099)
Wald-test of the significance of the instrument(s) for polytechnic choice	$p < 0.001$	$p < 0.001$	$p < 0.001$
LR-test for unobserved heterogeneity	50.84	32.64	168.2
	$p < 0.001$	$p < 0.001$	$p < 0.001$
Panel B: IV (GMM) estimates on the sample of polytechnic and vocational graduates (N = 152,758)			
Polytechnic vs. vocational education	0.0477***	0.0473***	-0.5891
	(0.0063)	(0.0056)	(0.9709)
LM test statistic for underidentification	10441	21117.1	1.4085
	$p < 0.001$	p < 0.001	$p = 0.235$
F statistic for weak identification	9503.3	16000.2	1.4171
Hansen J statistic		0.0188	
		($p = 0.891$)	
Panel C: IV (GMM) estimates on the full sample (N =233,839)			
Years of education	0.0370***	0.0256***	-0.3980***
	(0.0086)	(0.0079)	(0.1135)
LM test statistic for underidentification	2349.4	3256.3	29.179
	$p < 0.001$	$p < 0.001$	$p < 0.001$
F statistic for weak identification	2383.2	1654.6	28.551
Hansen J statistic	-	11.543	-
		(p < 0.001)	
Panel D: Logit model: marginal effects (N = 233,839)			
Polytechnic vs. vocational education	0.0429***		0.0600***
	(0.0112)		(0.0034)

Notes: N = Number of observations. See Table 3 in the main text for the full specification used in the baseline model (column 1). It uses polytechnic starting places as an instrument. Column (2) utilizes the polytechnic places squared as an additional instrument. Column (3) uses graduation year trend as an additional control variable. The marginal effects have been calculated using only mean characteristics of the vocational college and polytechnic graduates (Panels A and D). Heteroskedasticity-robust standard errors reported in parentheses. The reported LM and F tests for identification are Kleibergen-Paap (2006) rk statistics; see Kleibergen, F. and Paap, R. 2006. Generalized Reduced Rank Tests Using the Singular Value Decomposition. *Journal of Econometrics*, Vol. 133, pp. 97–126. Hansen J statistic of overidentifying restrictions tests for the validity instruments (i.e., they are uncorrelated with the error term). † Squared instruments are significant ($p < 0.01$). *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. If we use father's level of education and supply of polytechnic education as instruments in the marginal treatment effects model, the estimated marginal effect is 0.1025*** (0.0288).

Table S4. Effect of polytechnic education on six-year migration: sensitivity by type of model

	(1) Multinomial treatment model with quadratic instrument		(2) IV (GMM) with Linear instrument†	(3) IV (GMM) with quadratic instrument†	
	Estimated marginal effect	LR-test for unobserved heterogeneity	Estimated effect	Estimated effect	Hansen J statistic
All individuals					
Mean	0.0674**	p = 0.000	0.0477***	0.0473***	p = 0.891
Gender					
Male	0.0787***	p = 0.030	0.0705***	0.0679***	p = 0.598
Female	0.0511	p = 0.008	0.0301***	0.0325***	p = 0.484
Matriculated					
Yes	0.0709**	p = 0.000	0.0370***	0.0365***	p = 0.859
No	0.0609	p = 0.000	0.1132***	0.1107***	p = 0.815
Field of study					
Business	0.0570***	p = 0.000	0.0477***	0.0495***	p = 0.615
Technology	0.0593***	p = 0.148	0.0850***	0.0689***	p = 0.088
Health	0.0264**	p = 0.178	0.0005	-0.0021	p = 0.621
Graduation region					
Uusimaa	-0.0377***	p = 0.004	-0.0359***	-0.0455***	p = 0.000
Other regions	0.1069***	p = 0.000	0.1004***	0.0936***	p = 0.160

Notes: The marginal effects have been calculated using only mean characteristics of the vocational college and polytechnic graduates. The specifications for these sub-sample estimations are same as in Table 2 (see also Table 3) in the main text. Heteroskedasticity-robust standard errors reported in parentheses. † In all samples, the F test clearly rejects weak identification ($p < 0.001$). *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table S5. Effect of polytechnic education on six-year migration: results by field of study and gender

	Business		Technology		Health	
	Females	Males	Females	Males	Females	Males
Panel A: Multinomial treatment effect model: marginal effects						
Polytechnic vs. vocational education	0.0799***	0.0538***	0.0639	0.0730**	0.0300**	0.0033
	(0.0172)	(0.0179)	(0.0525)	(0.0315)	(0.0121)	(0.0429)
LR-test for unobserved heterogeneity	16.55	6.603	6.050	0.232	2.253	0.193
	$p < 0.001$	$p = 0.037$	$p = 0.049$	$p = 0.890$	$p = 0.324$	$p = 0.908$
Number of observations	49,560	24,063	8,183	38,181	41,679	6,235
Panel B: IV (GMM) estimates on the sample of polytechnic and vocational graduates with quadratic instrument						
Polytechnic vs. vocational education	0.0523***	0.0390**	0.0087	0.0832***	0.0029	-0.0131
	(0.0114)	(0.0186)	(0.0360)	(0.0149)	(0.0089)	(0.0317)
LM test statistic for underidentification	4696.6	1816.7	621.74	3125.6	7573.5	608.45
	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$
F statistic for weak identification	3578.9	1339.4	430.16	2050.5	8776.8	524.16
Hansen J statistic	0.745	0.651	2.028	2.270	1.055	2.295
	$p = 0.388$	$p = 0.420$	$p = 0.154$	$p = 0.132$	$p = 0.305$	$p = 0.130$
Number of observations	38,124	15,374	4,719	24,540	37,520	4,262
No. of polytechnic graduates	6,970	3,208	2,145	9,055	11,248	1,093

Notes: The marginal effects have been calculated using only mean characteristics of the vocational college and polytechnic graduates (Panel A). The specifications for these sub-sample estimations are same as in Table 2. Heteroskedasticity-robust standard errors reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table S6. Marginal effects of polytechnic education on six-year migration: changing dependent variable and sample

	Exogenous educ. choice	Endogenous educ. choice
Baseline		
The model reported in Table 3 in the paper	0.0429***	0.0878***
	(0.0112)	(0.0317)
Changing dependent variable		
Panel A: NUTS-4 (shorter-distance) migration	0.0399***	0.0810***
	(0.0118)	(0.0277)
Panel B: NUTS-2 (longer-distance) migration	0.0383***	0.0862***
	(0.0104)	(0.0258)
Panel C: Living in the graduation region after six-year follow-up period	-0.0361***	-0.0687***
	(0.0094)	(0.0303)
Panel D: Living in the secondary education region after six-year follow-up period	-0.0490***	-0.1161***
	(0.0094)	(0.0285)
Conditional on not migrated to post-secondary education:		
Panel E: Migrate during six-year follow-up period	0.0456***	0.0667***
	(0.0034)	(0.0093)
Conditional on migrated to post-secondary education:		
Panel F: Migrate during six-year follow-up period and not living in the secondary education region after the follow-up period (*onward migrate*)	0.0020	-0.0307***
	(0.0044)	(0.0109)
Panel G: Migrate during six-year follow-up period and living in the secondary education region after the follow-up period (*return migrate*)	0.0303***	0.0956***
	(0.0030)	(0.0062)

Notes: The number of observations is 233,839 in Panels A–D, 121,440 in Panel E and 112,399 in Panels F–G. The marginal effects have been calculated using mean characteristics of the vocational college and polytechnic graduates. Heteroskedasticity-robust standard errors reported in parentheses. *** $p < 0.01$. In all cases, LR-test rejects exogenous model ($p < 0.01$). Similarly, Hansen J statistic does not reject exogeneity of the instrument in all Panels A–G (smallest p-value is 0.17).

Table S7. Effect of polytechnic education on six-year migration: results by graduation year (t) from polytechnic education

	1995	1996	1997	1998	1999	2000	2001
Panel A: Multinomial treatment effect model: marginal effects							
Polytechnic vs.	0.4976***	0.3371***	0.3116***	0.1427***	0.0748***	0.0515***	0.0649***
vocational education	(0.1529)	(0.0696)	(0.0544)	(0.0238)	(0.0187)	(0.0145)	(0.0116)
LR-test for unobserved	31.41	41.33	41.36	24.35	9.842	13.79	13.80
heterogeneity	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p = 0.007$	$p = 0.001$	$p = 0.001$
Number of observations	102,704	102,876	101,481	98,689	96,669	92,476	86,373
Panel B: IV (GMM) estimates on the sample of polytechnic and vocational graduates with quadratic instrument							
Polytechnic vs. vocational	0.7816***	0.2528***	0.2410***	0.1430	0.1164*	0.0468	0.0595**
education	(0.2946)	(0.0642)	(0.0413)	(0.1041)	(0.0703)	(0.0364)	(0.0236)
LM test statistic for	73.896	623.15	1427.2	376.25	456.67	1084.8	2060.7
underidentification	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$
F statistic for weak identification	35.890	321.83	702.23	134.52	294.09	562.74	1111.3
Hansen J statistic	0.2198	4.8827	1.9247	4.6535	3.4497	1.7372	0.7968
	$p = 0.639$	$p = 0.027$	$p = 0.165$	$p = 0.031$	$p = 0.0633$	$p = 0.188$	$p = 0.372$
Number of observations	68,175	68,023	65,768	62,182	58,758	53,434	46,600
No. of polytechnic graduates	1,030	3,016	3,769	4,300	6,011	8,831	11,560

Notes: Each estimation uses polytechnic graduates from year t (e.g. 1995) and graduates from other levels from t, t–1,…, t–4 for identification. The marginal effects have been calculated using only mean characteristics of the vocational college and polytechnic graduates (Panel A). The specifications for these sub-sample estimations are same as in Table 2. Heteroskedasticity-robust standard errors reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table S8. Robustness checks of marginal effects of education on six-year migration (exogenous education choice)

	(1)	(2)	(3)	(4)	(5)	(6)
Polytechnic degree	0.0429***	0.0584***	0.0438***	0.0429***	0.0597***	0.0476***
	(0.0113)	(0.0105)	(0.0121)	(0.0115)	(0.0061)	(0.0085)
Master's degree	0.0851***	0.1000***	0.0953***	0.0875***	0.0929***	0.0855***
	(0.0121)	(0.0120)	(0.0123)	(0.0127)	(0.0103)	(0.0119)
Log-likelihood	-130,483	-127,040	-130,335	-130,429	-130,352	-130,273

Notes: The number of observations is 233,839 in all models (i.e. graduates from 1991–2001). Dependent variable: NUTS-3 migration during the graduation year or the following five years. The reference level of education is vocational college degree. Column (1) shows baseline; In column (2) potentially endogenous controls have been added (earnings, married or cohabiting, spouse's employment, has child). In column (3) field of education is defined with six categories instead of four; In column (4) migrated for studies dummy is replaced with living in the province of birth dummy; In column (5) year dummies have been added. In column (6) dummies for the secondary education region have been added. Marginal effects are calculated at the mean values of explanatory variables using logit model. Controls in (1) are defined in the Supplementary Appendix, Table S2. See Table S12 for definitions of additional controls. Heteroskedasticity-robust standard errors reported in parentheses allow for clustering on the graduation-region cells. *** $p < 0.01$.

Table S9. Marginal effects of education on six-year migration (exogenous education choice, full period 1988–2004)

	(1)	(2)	(3)	(4)	(5)
Polytechnic degree	0.0423***	0.0345***	0.0304**	0.0301**	0.0229**
	(0.0138)	(0.0128)	(0.0126)	(0.0141)	(0.0099)
Master's degree	0.0816**	0.1211***	0.0652***	0.0645***	0.0756***
	(0.0378)	(0.0212)	(0.0219)	(0.0212)	(0.0116)
Regional effects[a]	no	yes	yes	yes	yes
Migration for studies	no	no	yes	yes	yes
Field of education	no	no	no	yes	yes
Other controls	no	no	no	no	yes
Log-likelihood	-229,313	-219,512	-209,277	-209,210	-201,696
LR-test over restricted specification	–	$p < 0.001$ (df = 15)	$p < 0.001$ (df = 1)	$p < 0.001$ (df = 3)	$p < 0.001$ (df = 10)

Notes: The number of observations is 360,212 in all models. Dependent variable: NUTS-3 migration during the graduation year or the following five years. The reference level of education is vocational college degree. The marginal effects are calculated at mean values of explanatory variables using logit model (average pred. probability conditional on voc. college degree is 0.271 in model 5). Controls are defined in the Supplementary Appendix, Table S2. Heteroskedasticity-robust standard errors reported in parentheses allow for clustering on the graduation-region cells. df = degrees of freedom. [a] Include dummies for the secondary education region, graduation region and graduation year. *** p < 0.01, ** p < 0.05.

Table S10. Robustness checks of the marginal effects of education on six-year migration (endogenous education choice)

	(1)	(2)	(3)	(4)	(5)
Polytechnic degree	0.0883***	0.1154***	0.0872***	0.0812***	0.1116***
	(0.0318)	(0.0310)	(0.0286)	(0.0301)	(0.0252)
Master's degree	0.0746**	0.0944***	0.0840***	0.0721**	0.0817***
	(0.0309)	(0.0277)	(0.0258)	(0.0316)	(0.0267)
Log-likelihood	-251,471	-246,006	-244,653	-251,651	-246,438
LR-test for no unobserved heterogeneity	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$

Notes: The number of observations is 233,839 in all models (i.e. graduates from 1991–2001). Dependent variable: NUTS-3 migration during the graduation year or the following five years. The reference level of education is vocational college degree. Column (1) shows baseline; In column (2) potentially endogenous controls have been added (earnings, married or cohabiting, spouse’s employment, has child). In column (3) field of education is defined with six categories instead of four; In column (4) migrated for studies dummy is replaced with living in the province of birth dummy; In column (5) dummies for the secondary education region have been added. Marginal effects are calculated at the mean values of explanatory variables. Controls in (1) are defined in the Supplementary Appendix, Table S2. See Table S12 for definitions of additional controls. Heteroskedasticity-robust standard errors reported in parentheses allow for clustering on the graduation-region cells. *** $p < 0.01$, ** $p < 0.05$.

Table S11. Marginal effects of polytechnic education on migration: heterogeneity by sub-sample and length of follow-up period

	N	Three-year migration			Six-year migration		
		Exogenous educ. choice	Endogenous educ. choice		Exogenous educ. choice	Endogenous educ. choice	
All individuals							
Mean	233,839	0.0557***	0.1366***		0.0429***	0.0878***	
		(0.0126)	(0.0296)		(0.0112)	(0.0317)	
Gender							
Male	92,150	0.0760***	0.1776***		0.0550***	0.0987***	
		(0.0127)	(0.0287)		(0.0120)	(0.0275)	
Female	141,689	0.0422***	0.1034***		0.0340***	0.0655*	
		(0.0133)	(0.0323)		(0.0118)	(0.0347)	
Matriculated							
Yes	194,287	0.0531***	0.1378***		0.0373***	0.0914***	
		(0.0130)	(0.0264)		(0.0114)	(0.0313)	
No	39,552	0.0697***	0.0527		0.0716***	0.1396**	
		(0.0134)	(0.0848)		(0.0141)	(0.0565)	
Field of study							
Business	73,623	0.0678***	0.1193***		0.0488***	0.0707***	
		(0.0149)	(0.0137)		(0.0142)	(0.0129)	
Technology	46,364	0.0991***	0.1701***		0.0835***	0.0782***	†
		(0.0143)	(0.0282)		(0.0150)	(0.0280)	
Health	47,914	0.0162	0.0458***		0.0127	0.0280**	†
		(0.0128)	(0.0117)		(0.0105)	(0.0118)	
Graduation region							
Uusimaa	65,447	-0.0157***	-0.0264***	†	-0.0140***	-0.0289***	
		(0.0031)	(0.0075)		(0.0041)	(0.0097)	
Other regions	168,392	0.0795***	0.1759***		0.0588***	0.1190***	
		(0.0080)	(0.0210)		(0.0080)	(0.0216)	

Notes: N = Number of observations. The marginal effects have been calculated using only mean characteristics of the vocational college and polytechnic graduates. The coefficient shows the treatment effect of polytechnic vs. vocational college education on migration. The specifications are same as in the baseline. Heteroskedasticity-robust standard errors reported in parentheses allow for clustering on the graduation-region cells. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. † LR-test does not reject exogenous model ($p > 0.1$). In all other cases, exogenous model is rejected.

Table S12. Description of variables used only in the extensions and robustness checks

	Description	(1)	(2)
Dependent variables			
Three-year NUTS-3 migration	1 if person migrates between NUTS-3 regions during the post-secondary graduation year or the following two years, 0 otherwise	0.2707	0.2696
Six-year NUTS-4 migration	1 if migrating between NUTS-4 regions during the post-secondary graduation year or the following five years, 0 otherwise	0.3906	0.3932
Six-year NUTS-2 migration	1 if migrating between NUTS-2 regions during the post-secondary graduation year or the following five years, 0 otherwise	0.2710	0.2733
Living in the graduation region after six-year follow-up	1 if living in the graduation region five years after finishing post-secondary education; 0 otherwise	0.7085	0.7059
Living in the sec. educ. region after six-year follow-up period	1 if living in the graduation region five years after finishing post-secondary education; 0 otherwise	0.5774	0.5757
Instrument			
Father's level of education	Father's level of education with five dummies; basic education as the reference category	–	–
Control variables			
Earnings	Annual earnings subject to state taxation, 10,000 €	10.8784	10.3224
Married	1 if married or cohabiting, 0 otherwise	0.4040	0.4026
Sp. empl.	1 if spouse is employed, 0 otherwise	0.2807	0.2671
Children	1 if children under 18 years in the family, 0 otherwise	0.1191	0.1249
Field of education detailed	Field of education is defined with six categories instead of the four categories.	–	–
Graduate from the region of birth	1 if post-secondary graduation from the NUTS-3 region of birth; 0 otherwise	0.4578	0.4583
Number of observations		360,212	233,839

Notes: The control variables are measured on a year before an individual graduates from the first post-secondary education. Sample includes: (1) Full sample of graduates from 1988–2004; (2) Restricted sample of graduates from 1991–2001.

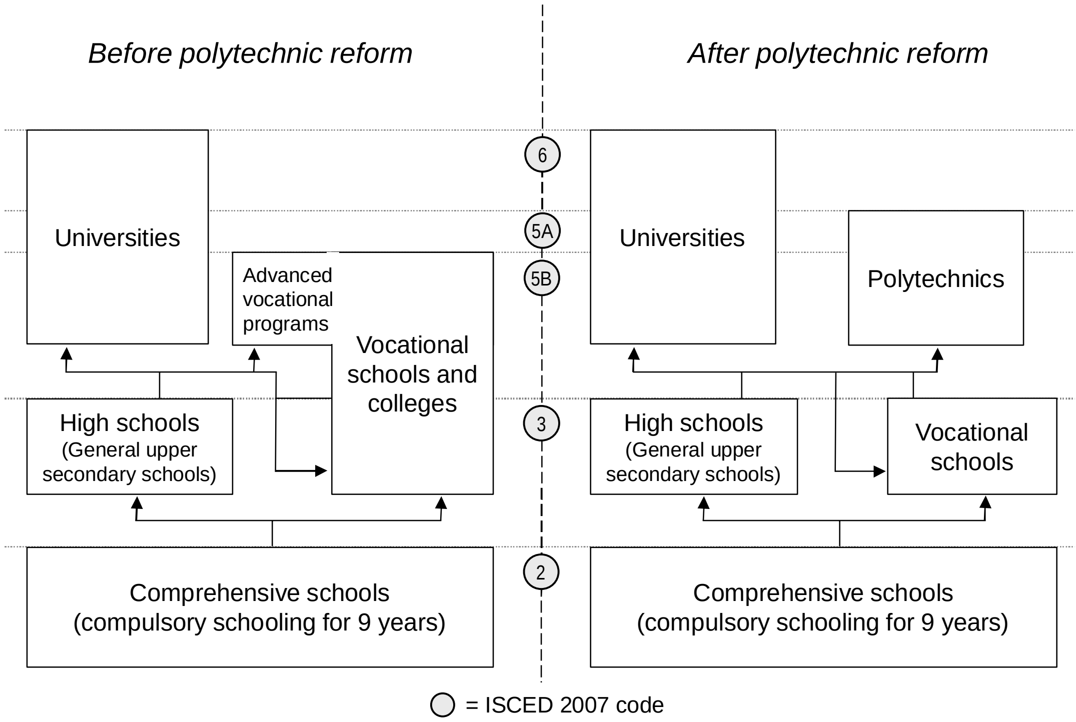


Figure S1. Illustration of the Finnish education system before and after the polytechnic reform in the 1990s.

See also following additional material:

- Statistics Finland. 1991. "Koulutus: Education in Finland 1991." Education and research 1991:11. Helsinki: Statistics Finland.
- UNESCO. 1997. "ISCED: International Standard Classification of Education." http://www.uis.unesco.org/Education/Pages/international-standard-classification-of-education.aspx.
- OECD. 2003. *Polytechnic Education in Finland*. Paris: OECD.

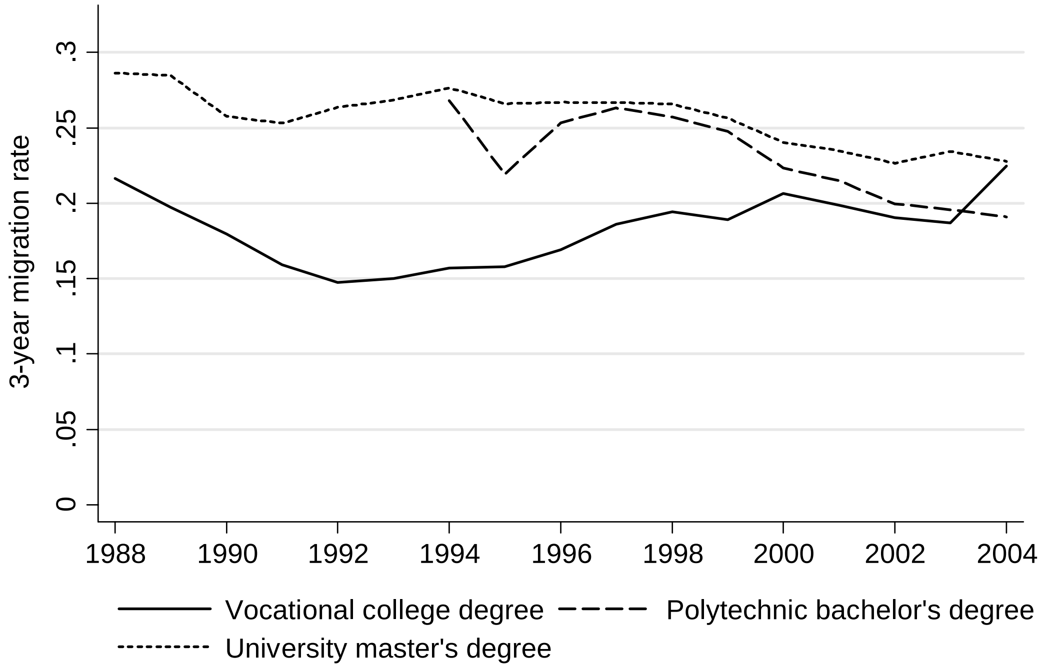


Figure S2. Three-year migration rates after graduation from the first post-secondary education (age less than 35 years).

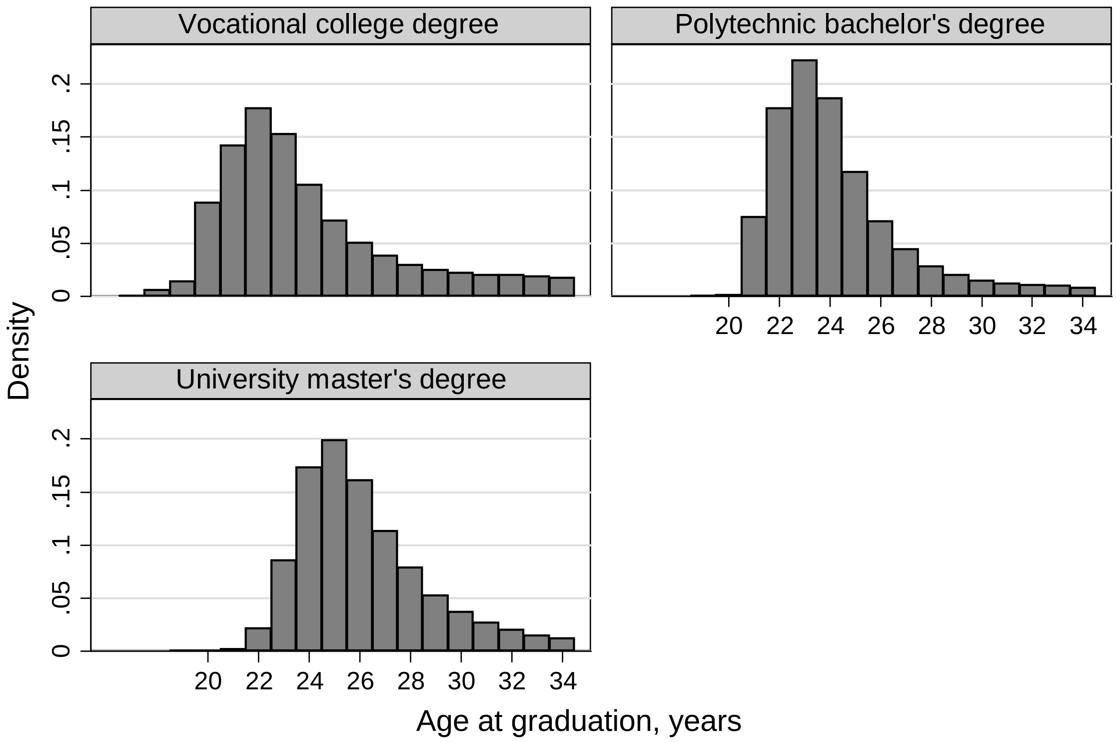


Figure S3. Histograms by the level of education: Age at the graduation from the first post-secondary education (age less than 35 years).

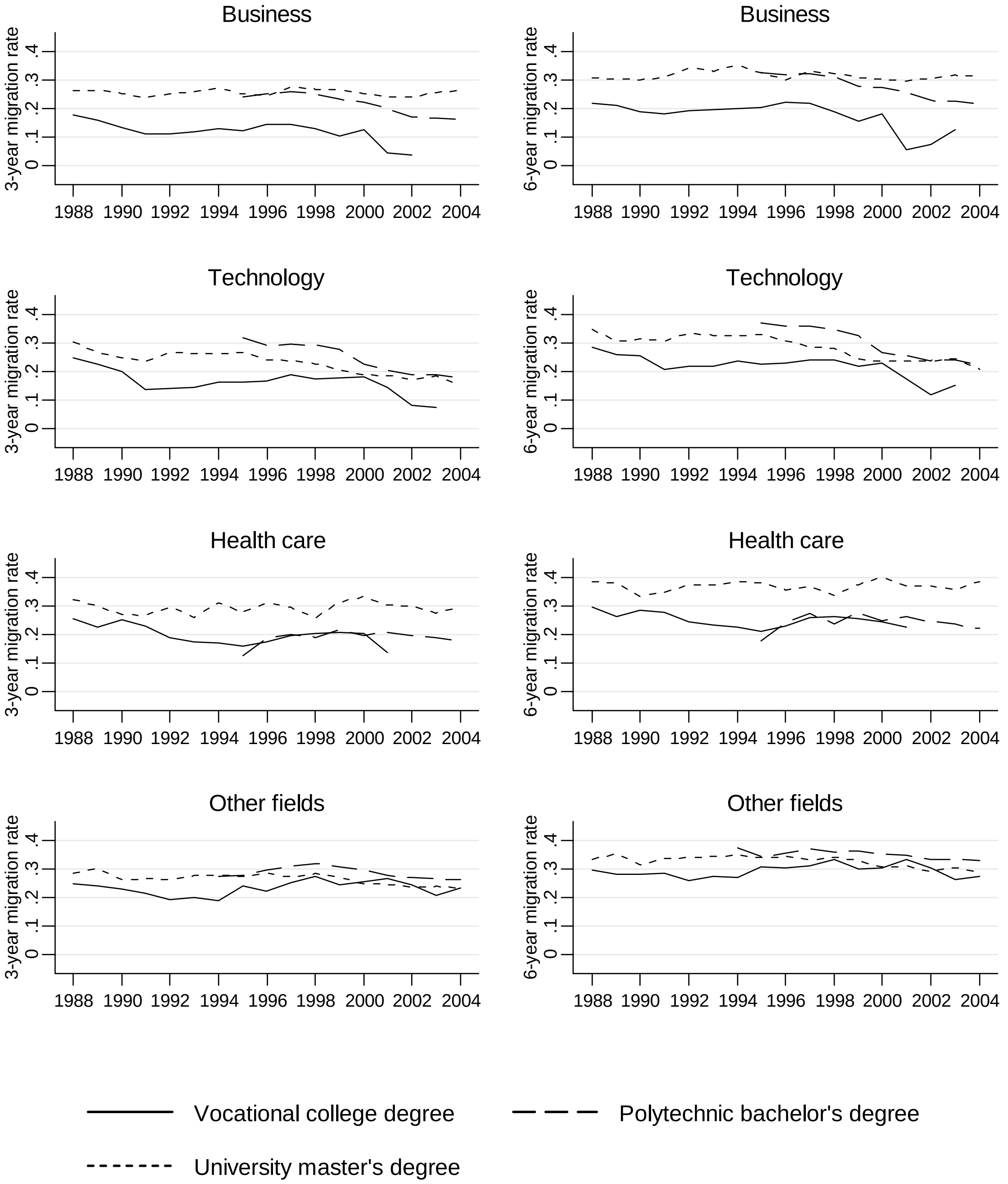


Figure S4. Three-year and six-year migration rates after graduation from vocational college or polytechnic degree in 1998–2004: Descriptive statistics by the field of education (own calculations from population data)