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ABSTRACT

More educated, more mobile? Evidence from post-secondary education reform. *Spatial Economic Analysis*. 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, it uses 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

摘要

更多教育、更能流动？高等教育改革的证据。空间经济分析。本文检视教育程度对于国内迁徙的因果影响。为了解释由选择进入高等教育所导致的偏见，本文运用芬兰在九O年代开始，逐渐将过往的技职学院改制为理工大学的高等教育系统中的大规模改革。此一改革随着时间在各区域的高等教育供给中，创造了半外在的变异。根据多项式处理效应模型和人口登记数据的结果显示，普遍而言，理工大学的毕业生较技职学院的毕业生而言，显着有更高的比例进行迁徙，尽管该评估会随着诸如性别、学习领域和区域而有所改变。

关键词

迁徙; 教育; 技职学院; 理工大学; 改革

RÉSUMÉ

Plus qualifié, alors plus mobile? Des résultats provenant de la réforme de l'éducation post-secondaire. *Spatial Economic Analysis*. Cet article cherche à examiner l'impact causal du niveau de l'éducation sur la migration à l'intérieur des pays. Pour tenir compte du biais dû à la sélection pour l'éducation post-secondaire, on se sert d'une importante réforme au sein du système d'enseignement supérieur et qui a progressivement transformé les anciens collèges d'enseignement professionnel en polytechnics (à savoir, instituts universitaires de technologie) en Finlande au cours des années 1990. Cette réforme a fini par une variation quasi-exogène quant à l'offre d'enseignement supérieur sur le temps et à travers les régions. Les résultats, qui

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proviennent non seulement d'un modèle multinomial des effets de traitement mais aussi des données d'un registre de population, montrent que, tout bien considéré, la probabilité que les diplômés des polytechnics vont se déplacer dépasse celle des diplômés des collèges d'enseignement professionnel, bien que les estimations varient, par sexe, par domaine d'études et par région, entre autres.

MOTS CLÉS
migration; éducation; collèges d'enseignement professionnel; polytechnics; réforme

RESUMEN
¿Más educados, más móviles? Evidencia de la reforma en la educación superior. *Spatial Economic Analysis*. En este artículo analizamos el impacto causal del nivel de educación en la migración dentro de un país. Para explicar los sesgos que ocurren en la selección para la enseñanza postsecundaria, se utiliza una reforma a gran escala en el sistema de educación superior de Finlandia que transformó gradualmente los antiguos institutos de formación profesional en escuelas politécnicas en la década de los noventa. Esta reforma creó una variación casi exógena en la oferta de educación superior con el tiempo y en todas las regiones. Los resultados basados en modelos de efectos de tratamiento multinomial y datos del registro de la población muestran que, en general, los graduados de escuelas politécnicas presentan una probabilidad significativamente mayor de emigrar que los graduados de los institutos de formación profesional, aunque las estimaciones varían, por ejemplo, en función del sexo, el campo de estudio y la región.

PALABRAS CLAVES
migración; educación; formación profesional; politécnica; reforma

JEL I21; R23
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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 United States; 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 ages of 15 and 50 years.

The causal evidence regarding post-secondary education and migration is even scarcer. Malamud and Wozniak (2012) use the variation in college attendance in the United States caused by draft-avoidance behaviour 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 behaviour. 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 7% 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 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 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 high-school 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 high-school graduation.

The paper is organized as follows. The second section discusses the theoretical arguments that link the level of education to migration. Section three describes the polytechnic education reform. The fourth section introduces the data. The fifth section describes the empirical modelling approach that allows for the endogeneity of education choice before migration. The results are reported in the sixth section; the final section concludes the paper.

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) labour economics textbook documents a higher migration rate between US 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).

Several theoretical explanations have been proposed for the positive relationship. Many of these are related to job-search behaviour. The first 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) find that the highly educated are more responsive to wages in alternative locations. In related research, Wozniak (2010) shows that the highly educated are also more responsive to local labour 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 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.

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 labour market stability (e.g., a smaller risk of unemployment, shorter unemployment spells and higher earnings) (e.g., Krabel & Flöther, 2014). This increases the opportunity costs of 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 (e.g., Faggian, McCann, & Sheppard, 2007; Jaeger et al., 2010). Still, some authors maintain that education affects migration only through its impact on earnings (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-determined by unobserved factors such as personality traits (e.g., a 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 (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.

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 cooperation between the fields of study. During the 10-year reform period, approximately 80% of the volume of education provided by the old post-secondary vocational colleges and schools was transformed into larger new polytechnics, while the remaining 20% continued to function in post-comprehensive vocational education (Organisation for Economic Co-operation and Development (OECD), 2003, pp. 50–52) (for a description of the Finnish education system before and after the reform, see Figure S1 in the supplemental data online).

Polytechnics provide high-level, non-academic vocational education (Lampinen, 2001). They offer bachelor-level degrees with a vocational emphasis that take from 3.5–4.5 years to complete. The first 22 polytechnics were established under a temporary licence 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.[3] 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 licences 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 relabelled as polytechnics (Lampinen, 2001; OECD, 2003; Välimaa & Neuvonen-Rauhala, 2008). The length of the studies increased, and according to a survey for teachers, programme 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 programme was expanded (e.g., to library and information services). The polytechnics are very actively engaged in research and development (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 signalling hypothesis of education (for further evidence on the labour market returns to polytechnic education, see Böckerman, Hämäläinen, and Uusitalo, 2009).

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 labour 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 labour market.

DATA

This study utilizes the newly assembled data on the total population of individuals under 70 years old in Finland between 1988 and 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 datasets 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 datasets, 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

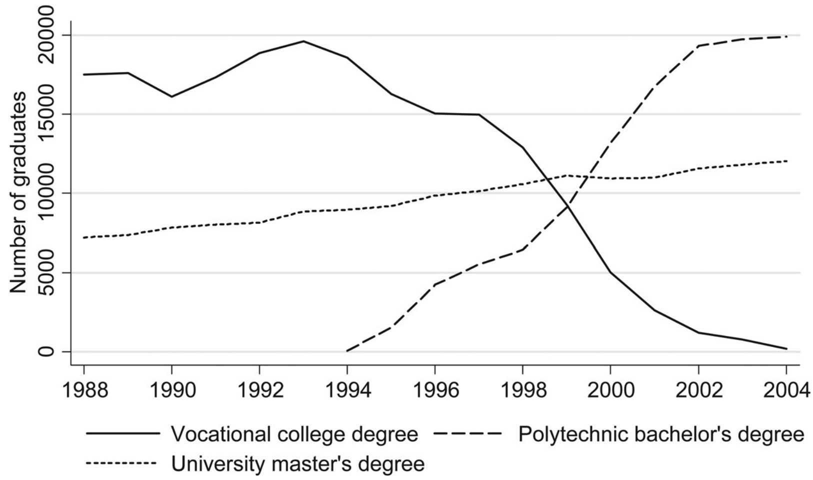

Figure 1. Vocational college, polytechnic and university graduates in Finland, 1988–2004.
Source: authors' own calculations from population data.

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) (for background information on the NUTS-3 regions, including a map, see Table S1 in the supplemental data online). These migration flows allow one to examine the changes in the geographical distribution of human capital; the average distance of a move among the graduation-year migrants is 229 kilometres. Migrating shorter distances between municipalities or sub-regions most likely reflects the housing market conditions rather than the labour 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.[4] 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 to 2001, so that they are from years close to the reform (including some years prior to the reform).

EMPIRICAL SPECIFICATIONS

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

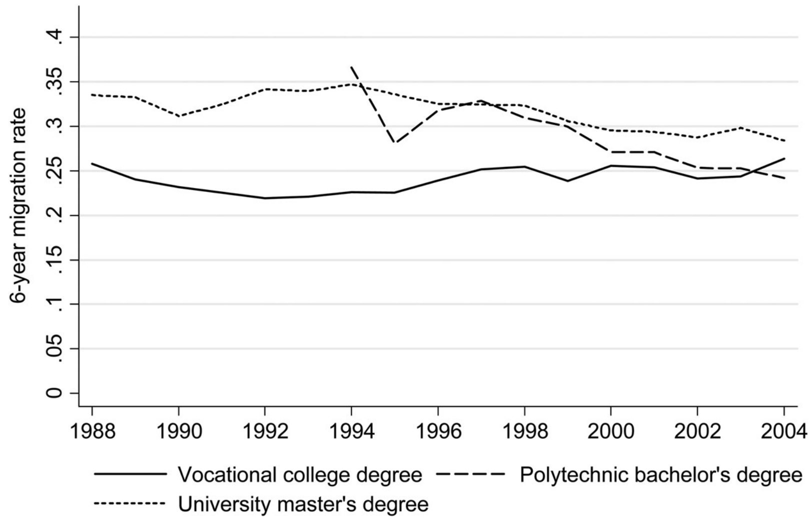

Figure 2. Six-year migration rates after graduation from the first post-secondary education (age less than 35 years).

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:

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

where m_i is a 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 supplemental data online 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) show 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 (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 if the previous qualification is from high school (instead of vocational school). Matriculation examination scores are available for those who have completed high school.[5] 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 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 labour 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 19–24-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 labour. 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.

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 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:

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

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 non-linear functional form, it is recommended for a more robust identification that an instrumental variable z_i be included in the education choice equation (2) but excluded from the migration equation (3) (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. 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 subpopulations that are reported below.

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 19–24-year-olds in the region as an additional control. To evaluate the exogeneity assumption, we utilize tests of over-identifying restrictions. Because there is no readily available test procedure for our non-linear setting, we have also estimated linear instrumental variables (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 over-identifying 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 supplemental data online presents the generalized method of moments (GMM) estimation results of the linear IV models.[6] They show that both instruments 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 subsample analyses reported in Tables S4 and S5 in the supplemental data online either. The only exception is the subsample of graduates from the Uusimaa region. To conclude, our instrument is both powerful and valid.[7]

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 1500 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 (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). Below 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.[8]

RESULTS

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 1991–2001. 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). Likelihood ratio (LR) 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%.

Education as endogenous

Next, we estimate the equations for the education choice and migration jointly, as described above. 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

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	–	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$
		(d.f. = 15)	(d.f. = 1)	(d.f. = 3)	(d.f. = 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 predicted probability conditional on vocational college is 0.268 in model 5). The marginal effects are calculated at the mean values of explanatory variables. The controls are defined in Table S2 in the supplemental data online. Heteroskedasticity-robust standard errors are reported in parentheses. d.f. = degrees of freedom. Likelihood ratio, LR.

[a]Includes graduation region dummies and regional unemployment rate. ***$p < 0.01$, **$p < 0.05$.

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

	Education choice		Migration Choice
	Polytechnic degree	Master's degree	
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)

(*Continued*)

Table 2. Continued.

	Education choice		Migration Choice
	Polytechnic degree	Master's degree	
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)
Matriculation 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 polytechnic 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

Note: The number of observations is 233,839. The log-likelihood is –251,471. The likelihood ratio (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). Results are based on the joint estimation of choice between the three levels of education (reference is vocational college degree) and moving during the graduation year or the following five years. The choice-specific constants and the dummy for the missing matriculation examination score are not reported for brevity. See Table S2 in the supplemental data online for the definitions of variables. Heteroskedasticity-robust standard errors are reported in parentheses. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

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 examination 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 examination score is particularly high for completing a master's degree.

The LR test results indicate the importance of controlling for the unobserved heterogeneity: the exogenous models are clearly rejected in favour of the endogenous models with the latent factors ($p < 0.001$). 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 with 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 (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 signalling 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). 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 (Machin et al., 2012; Malamud & Wozniak, 2012; Weiss, 2015).[9] 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 examination 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 versus 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.

Table 3, however, reveals considerable heterogeneity in the effects across subsamples.[10] Polytechnic education increases migration more for men than women and less for the matriculated (i.e., high-school graduates) than not matriculated. Thus, our results for Finland show that women not only have lower migration rates than men,[11] but also the effect of polytechnic education on migration is 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 healthcare fields. These results are consistent with Venhorst, Van Dijk, and Van Wissen (2010), who show that Dutch college graduates in the engineering and economics fields are more likely to move

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

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

Notes: Marginal effects were calculated using only the mean characteristics of the vocational college and polytechnic graduates. The specifications for these subsample 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.

from the peripheral regions to the economic centre of the country than college graduates in the healthcare 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 Table S5 in the supplemental data online 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 than for female technology field graduates; the reverse prevails for business and healthcare 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: (1) women are more likely to graduate from healthcare fields and less likely to graduate from technology fields than men; and (2) regardless of gender, the estimated effect of polytechnic education on migration is smaller in healthcare 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.[12] 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 labour markets are much thicker in Uusimaa compared with 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.

Additional analyses

We have also estimated the effect of polytechnic education on migration using alternative instrumental variables, alternative subsamples and alternative specifications of the dependent variable. These results are reported in the in the supplemental data online. We describe the results only briefly. When we utilize our instrument in quadratic form, the results remain qualitatively unchanged (see Table S3 in the supplemental data online). 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 (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 the note to Table S3 in the supplemental data online). 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, pp. 1822–1826) on the grounds that parental education often directly affects the offspring's labour market outcomes, such as earnings, or is at least correlated with the error term.

We have also altered the definition of migration. The supplemental data online reports the results for migration between 79 NUTS-4 (i.e., LAU-1)[13] sub-regions, instead of the NUTS-3 regions, and for longer-distance migration between the four NUTS-2 regions (see Table S6 in the supplemental data online). 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 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 supplemental data online). 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 with 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 IV models using GMM. First, we exclude graduates with a 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 (see Table S3 in the supplemental data online). 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).[14] To evaluate further 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 1996–2000. This five-year window improves the identification of the model. The results reported in Table S7 in the supplemental data online suggest that the effect of polytechnic education on migration was 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).

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 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 labour 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; and 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.

NOTES

1. Consistent with Schwartz (1973), Faggian and Franklin (2014) find for the United States 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.
2. Prior literature has demonstrated that student migration is also related to the quality of educational institutions and local labour 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 also that the migration rates after graduation are lower among graduates from high- than low-quality universities.
3. NUTS = Nomenclature des Unités Territoriales Statistiques.
4. The migration rates are computed as the total rates over the six-year follow-up period, instead of being presented as annual averages over the six-year period.
5. 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.
6. Multinomial treatment effects models and the linear IV models produce qualitatively similar results.
7. We 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).
8. We 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.
9. For example, Weiss's (2015) IV estimates of ever moving to another region are two to three times as large as the ordinary least squares (OLS) estimates.
10. As reported in Table S4 in the supplemental data online, the results are qualitatively similar when we estimate the models with linear IV instead of using the preferred multinomial treatment effect model.
11. This is contrary to the findings for UK university graduates, where female graduates are generally more geographically mobile than male graduates (Faggian et al., 2007).
12. 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 subsample.
13. LAU = local administrative unit.
14. We also conducted several additional analyses which are reported in Tables S8–S10 in the supplemental data online. For example, our results are robust for 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).

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