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Empirical modeling of internal migration and commuting flows for economic regions in Norway

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Abstract
This article provides empirical results for internal migration and commuting flows using panel data for 89 economic regions in Norway for the years 2001–2014. The emphasis is on the potential effects of different incentive variables. We consider both in- and out-migration as well as in- and out-commuting with a common set of explanatory variables. We perform panel data analysis for four educational groups using seemingly unrelated regression (SUR) models, acknowledging that the effects of the incentive variables may vary across educational groups. Generally, we find weak responses to the incentive variables for the eight response variables, but they differ somewhat across the educational groups. The group comprised of those with a low education appears to be most responsive. An increase in an economic region's relative wage rate leads to higher in-migration and lower out-migration for individuals with low education. Furthermore, an increase in an economic region's relative unemployment rate leads to lower in-migration whereas out-migration is left unaffected for individuals with this type of education. Besides, an increase in the relative unemployment rate leads to a significant reduction in in-commuting for this group.

JEL Classification C33 · C51 · J11 · J61

1 Introduction

Internal migration and commuting are important from several perspectives. Low internal mobility may hamper economic growth at the national level, as human resources are not optimally allocated. Norway has pursued a policy aimed at reducing out-migration from the districts, which is believed to have contributed to limiting the mobility. Another factor is a possible mismatch in the balance between in- and out-migration. In many parts of the country, there is negative population growth

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in both the short and the long run due to high out-migration and a low number of births (Leknes and Løkken 2020).[1] This makes it difficult to maintain public services and raises concerns over the sustainability of certain communities in the long run. Several municipalities run campaigns to motivate young persons to move back after finishing their education, but the effects of such efforts are often considered to be limited (NOU 2020: 15).

Commuting and internal migration are closely intertwined. Opportunities for commuting allow one to settle in less central areas without this being at the expense of opportunities to obtain satisfactory work. Reasons for choosing to settle in less central areas may, for example, be high housing prices in central areas or a preference for living in less densely populated areas. In general, more dynamic locations are expected to have higher in-commuting and in-migration rates. In addition, larger cities tend to yield higher rewards to human capital than rural areas (Ahlin et al. 2014). For out-migration/commuting the relationship is the reverse.

Internal migration and commuting constitute an old and well-established research area that has been approached from many angles. Sjaastad (1962) considers migration from the perspective of resource allocation. Over time, some industries expand while others experience downturns, and this gives rise to increased wage differentials across industries/occupations. Due to differences in business composition in different parts of the country, this change generates incentives for internal migration. By collecting information on the costs and returns of migration, it is in principle possible to assess whether the reallocations are sufficient to yield efficient allocation of labor.

We follow another common line of research which points to the relationship between economic incentives and geographic mobility; see for instance Greenwood (1975, 1985) and Mitze and Reinkowski (2011). However, the results from previous studies of economic driving forces have been somewhat inconsistent. For instance, Cebula (2005) considered gross state-level in-migration in the USA and found that per capita income had an effect, but unemployment rate differentials did not. Mitze and Dall Schmidt (2015), using Danish data, found mixed evidence of traditional incentive variables. Meanwhile, Piras (2012), using a cointegration framework on Italian data, found results with the expected signs for regional per capita GDP and unemployment rates, although the results varied somewhat with the different empirical specifications applied.

From a theoretical point of view, one should take into account that decisions to migrate and commute are taken simultaneously in order to maximize some target function, i.e., a utility function. The groundbreaking contribution by Monte et al. (2018), who consider the USA, provides a guideline to how this can be done within a general equilibrium context. To simplify model specifications and estimations, the empirical analysis in this article does not explicitly consider the close connection between migration and commuting.

Our analysis employs data for 89 Norwegian economic regions. The observation period is 2001–2014 and the individuals are between 20 and 64 years of age.

[1] In Norway birth rates are not particularly low in many districts, but the number of births might be low because the number of women of childbearing age is small.

Our main attention is on two incentive variables: the unemployment rate and the real hourly wage. In Norway, a relatively high fraction of workers are members of trade unions and economic policy is aimed at reducing geographic wage differences. Compared to other countries, the wage distribution has traditionally been relatively narrow, but over time the wage gap has widened.

This article makes two contributions. First, we allow gross migration and commuting flows to vary across four different educational groups. Thus, we allow responses to changes in relative real hourly wages and relative unemployment rates to differ across educational groups from the outset.[2] Many studies on internal migration illuminate the relationship between human capital and internal migration, even though human capital is not always the main issue addressed. However, many of them operate with a less detailed classification than that employed here. Examples include Devillanova (2004), Piras (2012), Clemente et al. (2013), Korpi and Clark (2017) and Epplesheimer and Möller (2019).

Second, we employ seemingly unrelated regression (SUR) models for panel data. The main reason for estimating a set of equations simultaneously is related to estimation efficiency. Faced with estimates that have the expected sign but low significance, valid parametric constraints applied across the equations produce more efficient estimates.

Our model specification differs from those of, for instance, Liu (2018) and Poghosyan (2018), in that we model not bilateral flows, but aggregate flows. That is, we consider the total inflows and outflows from the economic regions. An advantage of doing this is that we can use far more disaggregated data. In a setting with 89 observational units, a substantial number of observation pairs are characterized by zeros, for either one or both the observational units. This constitutes an issue when the models are specified in terms of log-transformed variables. Consistent with our choice, for each economic region we operate with 'outside' variables which are weighted averages of the values of the variables outside the economic region at hand. We use population shares for those aged 20–64 years as weights.

The group comprised of those with a low education appears to be most responsive. An increase in an economic region's relative wage rate leads to higher in-migration and lower out-migration for individuals with low education. Furthermore, an increase in an economic region's relative unemployment rate leads to lower in-migration whereas out-migration is left unaffected for individuals with this type of education. Besides, an increase in the relative unemployment rate leads to a significant reduction in in-commuting for this group.

It can be argued that our measure of 'outside' variables does not reflect the potential outcome of moving from one region to another if hourly wages are positively correlated with (labor market) populations size. To check this assumption, we carry out a robustness analysis in which we only use a part of the data focusing on internal migration and commuting from small to large economic regions.

[2] In contrast, Carlsen et al. (2013) modelled net internal migration rates and they also used another education classification than what we employ. Their interest was also directed to heterogeneous response to incentive variables by different education groups.

The rest of the article is organized as follows: In Sect. 2, we specify our econometric models and make various assumptions. Section 3 provides information on the data. In Sect. 4, we present and discuss our empirical results both for the specification of the main models and for those involved in the robustness analysis. We conclude in Sect. 5. Some technical documentation may be found in the appendices.

2 Model specification

A typical equation for internal migration may be written as

$$\begin{aligned}\log(MIG_{it}^{de}) &= \mu_i^{Mde} + \lambda_t^{Mde} + \beta^{Mde}\log(POP_{it}^{e}) + \gamma^{Mde} \times [\log(UR_{i,t-1}^{e}) - \log(UROTH_{i,t-1}^{e})] + \\ &\theta^{Mde} \times [\log(RHWAGE_{i,t-1}^{e}) - \log(RHWAGEOTH_{i,t-1}^{e})] + \\ &\eta^{Mde} \times [\log(EMPSHARE_{i,t-1}^{e}) - \log(EMPSHAREOTH_{i,t-1}^{e})] + \varepsilon_{it}^{Mde}.\end{aligned} \tag{1}$$

The left-hand variable, $\log(MIG_{it}^{de})$, is the log of an internal migration flow for region i in period t for an educational group. The superscript $d=\{IN, OUT\}$ indicates inflow or outflow and the superscript $e=\{LOW, VOC, SUS, HIGH\}$ indicates educational category.[3] The superscript M, occurring on the right-hand side of Eq. (1), stands for migration (in contrast to commuting). The observed variables on the right-hand side of (1) are the log of the population with education type e at the beginning of year t,$\log(POP_{it}^{e})$, the relative difference in the unemployment rate between region i and other regions among those belonging to education category e in period t-1, $\log(UR_{t-1}^{e}) - \log(UROTH_{i,t-1}^{e})$, the relative difference in the average real hourly wage[4] in region i and other regions among those belonging to education category e in period $t-1$, $\log(RHWAGE_{i,t-1}^{e}) - \log(RHWAGEOTH_{i,t-1}^{e})$ and the relative difference in the employment share in region i and in other regions among those belonging to education category e in period $t-1$, $\log(EMPSHARE_{i,t-1}^{e}) - \log(EMPSHAREOTH_{i,t-1}^{e})$. Altogether, (1) contains 8 equations, combining internal inflows and outflows of migrants with four different types of education. The eight equations in (1) are estimated as a set of regression equations. The contemporaneous error terms are assumed to be correlated, but free from autocorrelation and heteroskedasticity. The parameters in this model are estimated by iterative SUR estimation until convergence, which under normality assumptions yields maximum likelihood estimates.

When analyzing commuting patterns, we apply the same explanatory variables as for internal migration rates. We now have the following equations:

[3] For how the educational categories are operationalized see Table 13 in Appendix C.

[4] Sometimes, we use the shorter form 'relative real wage' instead of the more complete term 'the relative difference in the average real hourly wage'.

$$\log(COM_{it}^{de}) = \mu_i^{Cde} + \lambda_t^{Cde} + \beta^{Cde}\log(POP_{it}^{e}) + \gamma^{\mathrm{Cde}} \times [\log(UR_{i,t-1}^{e}) - \log(UROTH_{i,t-1}^{e})] + \theta^{Cde} \times [\log(RHWAGE_{i,t-1}^{e}) - \log(RHWAGEOTH_{i,t-1}^{e})] + \eta^{Cde} \times [\log(EMPSHARE_{i,t-1}^{e}) - \log(EMPSHAREOTH_{i,t-1}^{e})] + \varepsilon_{it}^{Cde}. \quad (2)$$

The superscript C stands for commuting. The left-hand variable is the log of a commuting flow related to region i in period t for a specific educational group.

3 Data[5]

We combine data from different sources for the years 2001–2014. The stock and flow population data are taken from the Population Statistics of Statistics Norway. The population stocks relate to where individuals reside at the beginning of the year and cover persons in the age interval 20–64 years. From the employment statistics, we have information on the labor market status of each person and where workers have their main job. A third data source is Statistics Norway's education statistics (NUDB). These statistics provide data on the highest education achieved by the individuals in terms of duration and type. Appendix Table 13 provides an exact definition of the educational groupings we employ according to the Norwegian Standard Classification of Education; see Barrabés and Østli (2016). Data have been aggregated from municipal to regional level; see Appendix Table 12 for an overview of the regions.[6] We utilize this information to calculate time series for educational-specific unemployment rates for the economic regions. Utilizing data for those individuals who are employees, we can calculate time series of mean hourly wage rates for the different educational categories in the economic region. The mean hourly wages used are those of individuals who are full-time workers. To calculate real hourly wages, we deflate by the consumer price index. Combining information from the population statistics, employment statistics and educational statistics, we also calculate educational-specific time series for employment shares at the level of the economic regions. This share is defined as the ratio between the number of employed individuals with a specific education to the total number of individuals with this type of education in the age interval 20–64 years.

In our empirical analysis, we consider relative real hourly wages, relative unemployment rates and relative employment shares. By relative real hourly wage, we mean real hourly wage compared to a mean real wage level in economic regions

[5] See Table 11 in Appendix A for an overview of definition of variables that one encounters in the main part of the article.

[6] The classification of economic regions corresponds to what is referred to by Statistics Norway as the NUTS 4 level.

other than the one being considered. We define the mean real hourly wage outside economic region i for a specific educational group as

$$RHWAGEOTH^{e}_{it} = \frac{\sum_{j \in R_i} POP^{e}_{jt} \times RHWAGE^{e}_{jt}}{\sum_{j \in R_i} POP^{e}_{jt}}, \; i \in R; e = \{LOW, \; VOC, \; SUS, \; HIGH\}, \tag{3}$$

where R is the set containing all the (89) observational units and R_i is a subset of R consisting of all the regions except region i (88).

This means that the 'outside' real hourly wage of a specific educational group is a weighted (time-varying) mean of the real hourly wage outside the economic region, where weights are based on the size of the (target) population with the selected type of education. We use similar formulae for the unemployment rates and the employment shares. They are given by

$$UROTH^{e}_{it} = \frac{\sum_{j \in R_i} POP^{e}_{jt} \times UR^{e}_{jt}}{\sum_{j \in R_i} POP^{e}_{jt}}, i \in R; \; e = \{LOW, VOC, SUS, HIGH\} \tag{4}$$

and

$$EMPSHAREOTH^{e}_{it} = \frac{\sum_{j \in R_i} POP^{e}_{jt} \times EMPSHAREOTH^{e}_{jt}}{\sum_{j \in R_i} POP^{e}_{jt}}, i \in R; \; e = \{LOW, VOC, SUS, HIGH\}. \tag{5}$$

In Appendix D, we report measures related to the variables real hourly wage and unemployment rate. First, we calculate annual coefficients of variation to see whether the cross-sectional dispersion has changed over time. These are reported in Tables 14 and 15. The main impression is that spread changes moderately over time. With respect to the real hourly wage variable for the group with high education, there was a slight increase in dispersion in the first half of the observation period, but then it flattened out. There is a weak downward trend in the dispersion of the unemployment rates. This is seen for all educational groups, but the pattern is most pronounced in the three groups vocational, study-oriented upper secondary and high education. We sort the cross-sectional data for each of the years and give each economic region a ranking number. We can then calculate the empirical correlation between the rank variables for different years. This yields information on the stability of an economic region's place in the distribution. Tables 16 and 17 portray estimates for those with low education, Tables 18 and 19 for those with vocational education, Tables 20 and 21 for those with study-oriented upper secondary education, whereas Tables 22 and 23 show estimates for those with high education. When Table 16 is compared with Table 17, Table 18 with Table 19, Table 20 with Table 21 and Table 22 with Table 23, we see that the ranking correlations are higher for the real hourly wage variable than for the unemployment rates for all educational groups. The correlations tend to decrease with the distance in years. Thus, there is some convergence between the economic regions over time.

4 Empirical results

When it comes to the unknown parameters in Eqs. (1) and (2), we expect the population parameters to enter with a positive sign. A larger observational unit population should generate higher inflows as well as higher outflows. We expect the relative real wage to enter positively for in-migration and in-commuting and negatively for out-migration and out-commuting. The relative unemployment rate is expected to enter with a negative sign for in-migration and in-commuting. For reasons of symmetry, we expect the relative unemployment rate to enter with a positive sign in connection with out-migration and out-commuting. Finally, we expect the employment share to enter with a positive sign for in-migration and in-commuting and with a negative sign for out-migration and out-commuting. A high employment share in an economic region may signal that the labor market functions well and the expected signs related to the employment share variable are in accordance with such a view. Recall that all observed variables in the models except the regional and annual dummies are log-transformed.

5 Results for internal migration

For (internal) migration, we consider a set of regressions consisting of the eight response variables

$$\log(MIG_{it}^{IN,\ LOW}), \log(MIG_{it}^{IN,\ itVOC}), \log(MIG_{it}^{IN,\ SUS}), \log(MIG_{it}^{IN,\ HIGH}), \log(MIG_{it}^{OUT,\ LOW}),$$

$$\log(MIG_{it}^{OUT,VOC}), \log(MIG_{it}^{OUT,SUS}) \text{ and } \log(MIG_{it}^{OUT,HIGH}).$$

The equation for each of these variables is given by (1). The assumptions with respect to the error terms have been stated above in a qualitative way but are given a formal treatment here. Let

$$\begin{aligned}\varepsilon_{\mathrm{it}}^{M} = \{&\varepsilon_{it}^{M,\ IN,\ LOW},\ \varepsilon_{it}^{M,\ IN,\ VOC}, \varepsilon_{it}^{M,\ IN,\ SUS}, \varepsilon_{it}^{M,\ IN,\ HIGH},\\ &\varepsilon_{it}^{M,\ OUT,\ LOW},\ \varepsilon_{it}^{M,\ OUT,\ VOC}, \varepsilon_{it}^{M,\ OUT,\ SUS}, \varepsilon_{it}^{M,\ OUT,\ HIGH}\}'.\end{aligned} \tag{6}$$

We assume $\varepsilon_{it}^{M} \sim \mathrm{NIID}(\underline{0}, \Omega^{M})$, where $\underline{0}$ is an 8×1 vector with only zeros and Ω^{M} is a symmetric and positive definite but otherwise unrestricted covariance matrix containing 36 s-order moments of the errors.

In view of the preliminary estimation results, we constrained some parameters to zero. The estimation results for a restricted case are reported in Table 1. Table 2 reports the standard error of regression (SER) for each of the estimated equations and Table 3 reports the estimation results in qualitative form. Table 1 is ordered such that the results for the four inflow equations are reported first followed by the results for the four outflow equations. We comment on the estimation results for the inflow equations first. According to the results in Table 1, there is a weak relative unemployment effect for the groups with low and vocational education, but the effects are not statistically significant at 5 percent significance level. For the two remaining groups, the unemployment effect has been constrained to zero because of the low

Table 1 Internal migration. Iterative SUR-estimates

Left-hand variable	Parameter	Type of variable	Estimate	*t*-value
$\log(MIG_{it}^{IN,\,LOW})$	$\beta^{M,IN,\,LOW}$	Population	0.756	7.251
	$\gamma^{M,IN,\,LOW}$	Unemployment	−0.044	−1.618
	$\theta^{M,IN,\,LOW}$	Real wage	0.277	1.839
	$\eta^{M,IN,\,LOW}$	Employment share	0[a]	
$\log(MIG_{it}^{IN,\,VOC})$	$\beta^{M,IN,\,VOC}$	Population	0.958	11.190
	$\gamma^{M,IN,\,VOC}$	Unemployment	−0.029	−1.528
	$\theta^{M,IN,\,VOC}$	Real wage	0[a]	
	$\eta^{M,IN,\,VOC}$	Employment share	0[a]	
$\log(MIG_{it}^{IN,\,SUS})$	$\beta^{M,IN,\,SUS}$	Population	0.836	6.477
	$\gamma^{M,IN,\,SUS}$	Unemployment	0[a]	
	$\theta^{M,IN,\,SUS}$	Real wage	0.609	2.624
	$\eta^{M,IN,\,SUS}$	Employment share	0[a]	
$\log(MIG_{it}^{IN,\,HIGH})$	$\beta^{M,IN,\,SUS}$	Population	1.045	12.108
	$\gamma^{M,IN,\,SUS}$	Unemployment	0[a]	
	$\theta^{M,IN,\,SUS}$	Real wage	0[a]	
	$\eta^{M,IN,\,SUS}$	Employment share	0[a]	
$\log(MIG_{it}^{OUT,\,LOW})$	$\beta^{M,OUT,\,LOW}$	Population	0.957	15.910
	$\gamma^{M,OUT,\,LOW}$	Unemployment	0[a]	
	$\theta^{M,OUT,\,LOW}$	Real wage	−0.118	−1.776
	$\eta^{M,OUT,\,LOW}$	Employment share	−0.505	−2.530
$\log(MIG_{it}^{OUT,\,VOC})$	$\beta^{M,OUT,\,VOC}$	Population	1.130	20.386
	$\gamma^{M,OUT,\,VOC}$	Unemployment	0[a]	
	$\theta^{M,OUT,\,VOC}$	Real wage	−0.118[b]	
	$\eta^{M,OUT,\,VOC}$	Employment share	0[a]	
$\log(MIG_{it}^{OUT,\,SUS})$	$\beta^{M,OUT,\,SUS}$	Population	1.412	10.780
	$\gamma^{M,OUT,\,SUS}$	Unemployment	0.037	1.933
	$\theta^{M,OUT,\,SUS}$	Real wage	0[a]	
	$\eta^{M,OUT,\,SUS}$	Employment share	0[a]	
$\log(MIG_{it}^{OUT,\,HIGH})$	$\beta^{M,OUT,\,HIGH}$	Population	1.263	22.676
	$\gamma^{M,OUT,\,HIGH}$	Unemployment	0[a]	
	$\theta^{M,OUT,\,HIGH}$	Real wage	−0.118[b]	
	$\eta^{M,OUT,\,HIGH}$	Employment share	0[a]	

Region-specific fixed effects and annual fixed effects are included in all equations. *t*-values are based on heteroskedasticity-consistent estimates of standard errors

[a]A priori zero restriction

[b]A priori restrictions: $\theta^{M,OUT,\,LOW}=\theta^{M,OUT,\,VOC}=\theta^{M,OUT,\,HIGH}$

significance of the estimates. When it comes to relative real wage, there is a significant and positive effect on those with study-oriented upper secondary education. There is also a weak positive, but insignificant (at the 5 percent level), effect for the

Table 2 Standard errors of regression from a system of eight equations. Internal migration

$\log(MIG_{it}^{IN,\ LOW})$	0.129
$\log(MIG_{it}^{IN,\ VOC})$	0.134
$\log(MIG_{it}^{IN,\ SUS})$	0.173
$\log(MIG_{it}^{IN,\ HIGH})$	0.139
$\log(MIG_{it}^{OUT,\ LOW})$	0.112
$\log(MIG_{it}^{OUT,\ VOC})$	0.114
$\log(MIG_{it}^{OUT,\ SUS})$	0.131
$\log(MIG_{it}^{OUT,\ HIGH})$	0.096

group with low education. For the two remaining groups, the effect has been set to zero because of low significance in preliminary estimation rounds. For all the educational groups, we have set the effect of the employment share to zero because of low significance in preliminary estimation rounds.

Let us next turn to the outflow equations. Here, a positive effect of the relative unemployment rate is found for those with study-oriented upper secondary education. The estimate is almost significant at the 5 percent test level. For the three other groups, the effect is set to zero. The coefficients of the relative real wage variables are constrained to be the same for all groups except for those with study-oriented upper secondary education, where it is constrained to be zero. The common parameter estimate is negative with a significance probability of about 7.5 percent. The relative employment share enters significantly and negatively only for those with low education. The population size variable enters significantly in all eight equations with a value centering around to unity. As seen from Table 2, the standard errors of regression vary from 0.096 to 0.173.[7]

6 Results for commuting

As for internal migration, we estimated a SUR specification for commuting workers. Again, there are eight equations. The first four equations are for inflow of commuting workers with different educational backgrounds, while the last four are for outflow of commuting workers with different educational backgrounds. The empirical results are reported in Table 4. Table 5 reports the standard error of regression for each equation and Table 6 provides qualitative estimation results. From the results in Table 4, we see that the relative real wage only plays a role for inflow commuting for those with low education. The relative unemployment rate variable enters significantly with the expected negative sign for those with low and vocational education. The estimate is largest (in absolute value) for those

[7] One should recall that variables for inflow and outflow of internal migrants also involve individuals who, for different reasons, do not participate in the labor market. To what degree internal migration by such individuals are affected by changes in the incentive variables is an issue we do not explicitly address in this article.

Table 3 Qualitative summary of results. Internal migration[a]

Educational group	Type of flow variable	Rel. wage	Rel. unemp. rate	Rel. empl. share
LOW	Inflow	(+)	(–)	
	Outflow	(–)		–
VOC	Inflow		(–)	
	Outflow	(–)		
SUS	Inflow	+		
	Outflow		(+)	
HIGH	Inflow			
	Outflow	(–)		

[a]A cell with '–' denotes a negative estimate with a *t*-value higher than 2 in absolute value. A cell with '(–)' denotes a negative estimate with a *t*-value higher than 1.5 but lower than 2 in absolute value. A cell with '+' denotes a positive estimate with a *t*-value higher than 2. A cell with '(+)' denotes a positive estimate with a *t*-value higher than 1.5 but lower than 2

with low education with a point estimate of -0.07 and *t*-value of about 2.6 in absolute value. For those with study-oriented upper secondary education, we also report a negative estimate, but here the *t*-value is only around 1 in absolute value. For those with high education, the effect is set to zero. The relative employment share variable enters with a positive estimate for those with low and vocational education. They are both significant at the 5 percent level. For those with study-oriented upper secondary and high education, the effects are set to zero.

Lastly, we turn to the results for outflow of commuting workers. For those with low and vocational education, we do not find any effect for any of the three incentive variables. For those with study-oriented upper secondary and high education, we obtain negative estimates of the effects related to the relative wage variable. The point estimate is rather equal for the two groups, but the significance is most pronounced for those with high education. For this group, the estimate is significant at the 5 percent test level, whereas the significance probability is slightly above 5 percent for those with study-oriented upper secondary education. The relative unemployment rate only plays a role for those with study-oriented upper secondary education. However, the positive estimate only has a *t*-value around 1.4. The relative employment share enters with a negative estimate for those with study-oriented upper and high education. The estimated effect is significant at the 5 percent significance level for those with high education whereas the significance probability for those with study-oriented secondary upper education is about 10 percent.

7 A robustness analysis

So far, our measure of 'outside' variables has been based on data for all the 88 outside regions. If there is a positive correlation between population size and hourly wages at the regional level, and/or a negative correlation between population size and the unemployment rate, the potential benefit from moving from one region to

Table 4 Iterative SUR-estimates in a set of regression models for commuting

Left-hand variable	Parameter	Type of variable	Estimate	*t*-value
$\log(COM_{it}^{IN,\ LOW})$	$\beta^{C,\ IN,\ LOW}$	Population	1.025	8.293
	$\gamma^{C,\ IN,\ LOW}$	Unemployment	−0.072	−2.612
	$\theta^{C,\ IN,\ LOW}$	Real wage	0.302	2.448
	$\eta^{C,\ IN,\ LOW}$	Employment share	0.505	2.221
$\log(COM_{it}^{IN,\ VOC})$	$\beta^{C,\ IN,\ VOC}$	Population	1.150	10.873
	$\gamma^{C,\ IN,\ VOC}$	Unemployment	−0.046	−2.253
	$\theta^{C,\ IN,\ VOC}$	Real wage	0[a]	
	$\eta^{C,\ IN,\ VOC}$	Employment share	0.813	2.099
$\log(COM_{it}^{IN,\ SUS})$	$\beta^{C,\ IN,\ SUS}$	Population	0.906	7.816
	$\gamma^{C,\ IN,\ SUS}$	Unemployment	−0.021	−1.048
	$\theta^{C,\ IN,\ SUS}$	Real wage	0[a]	
	$\eta^{C,\ IN,\ SUS}$	Employment share	0[a]	
$\log(COM_{it}^{IN,\ HIGH})$	$\beta^{C,\ IN,\ HIGH}$	Population	0.915	9.963
	$\gamma^{C,\ IN,\ HIGH}$	Unemployment	0[a]	
	$\theta^{C,\ IN,\ HIGH}$	Real wage	0[a]	
	$\eta^{C,\ IN,\ HIGH}$	Employment share	0[a]	
$\log(COM_{it}^{OUT,\ LOW})$	$\beta^{C,\ OUT,\ LOW}$	Population	0.758	15.036
	$\gamma^{C,\ OUT,\ LOW}$	Unemployment	0[a]	
	$\theta^{C,\ OUT,\ LOW}$	Real wage	0[a]	
	$\eta^{C,\ OUT,\ LOW}$	Employment share	0	
$\log(COM_{it}^{OUT,\ VOC})$	$\beta^{C,\ OUT,\ VOC}$	Population	0.791	13.043
	$\gamma^{C,\ OUT,\ VOC}$	Unemployment	0[a]	
	$\theta^{C,\ OUT,\ VOC}$	Real wage	0[a]	
	$\eta^{C,\ OUT,\ VOC}$	Employment share	0[a]	
$\log(COM_{it}^{OUT,\ SUS})$	$\beta^{C,\ OUT,\ SUS}$	Population	0.782	8.826
	$\gamma^{C,\ OUT,\ SUS}$	Unemployment	0.019	1.381
	$\theta^{C,\ OUT,\ SUS}$	Real wage	−0.183	−1.907
	$\eta^{C,\ OUT,\ SUS}$	Employment share	−0.294	−1.634
$\log(COM_{it}^{OUT,\ HIGH})$	$\beta^{C,\ OUT,\ HIGH}$	Population	0.798	17.621
	$\gamma^{C,\ OUT,\ HIGH}$	Unemployment	0[a]	
	$\theta^{C,\ OUT,\ HIGH}$	Real wage	−0.157	−3.108
	$\eta^{C,\ OUT,\ HIGH}$	Employment share	−0.592	−2.375

[a]A priori zero restriction

Region-specific fixed effects and annual fixed effects are included in all equations. *t*-values are based on heteroskedasticity-consistent estimates of standard errors

another depends on the population size in the two regions. In this case, our measure of 'outside' variables might not fully capture this benefit. To check if our estimation results are robust to this hypothesis, we now split the 89 economic regions into two main groups for economic regions according to population size, main regional

Table 5 Standard errors of regression from a system of eight equations. Commuting

$\log(COM_{it}^{IN,\,LOW})$	0.141
$\log(COM_{it}^{IN,\,VOC})$	0.138
$\log(COM_{it}^{IN,\,SUS})$	0.140
$\log(COM_{it}^{IN,HIGH})$	0.113
$\log(COM_{it}^{OUT,\,LOW})$	0.077
$\log(COM_{it}^{OUT,\,VOC})$	0.075
$\log(COM_{it}^{OUT,\,SUS})$	0.086
$\log(COM_{it}^{OUT,\,HIGH})$	0.078

Table 6 Summary of results, qualitative. Commuting[a]

Educational group	Type of flow variable	Rel. wage	Rel. unemploy. rate	Rel. empl. share
LOW	Inflow	+	–	+
	Outflow			
VOC	Inflow		–	+
	Outflow			
SUS	Inflow			
	Outflow	(–)		(–)
HIGH	Inflow			
	Outflow	–		–

[a]A cell with '–' denotes a negative estimate with a *t*-value higher than 2 in absolute value. A cell with '(–)' denotes a negative estimate with a *t*-value higher than 1.5 but lower than 2 in absolute value. A cell with '+' denotes a positive estimate with a *t*-value higher than 2. A cell with '(+)' denotes a positive estimate with a *t*-value higher than 1.5 but lower than 2

group 1 and 2. The most populous economic regions are in group 1, whereas the less populous economic regions are in group 2. Assuming the division is the same for all years, the number of economic regions in main groups 1 and 2 is 32 and 57, respectively.[8] We estimate four sets of regressions each containing 4 equations, corresponding to the four education categories. Two of the sets are related to internal migration and two are related to commuting. With respect to internal migration we look at (i) in-migration to group 1 from group 2 and (ii) out-migration from the small economic regions, i.e., those in main group 2, to main group 1. Thus, the

[8] Below we use the short forms group 1 and group 2. In the next last column of Table 12 in Appendix B we inform on which main group each of the 89 economic regions belongs to. For each economic region we have calculated the mean number of individuals aged 20–64 years for the years 2001–2014. If this mean exceeds 20,000 for an economic region it belongs to main group 1 for the entire sample period, i.e., 2001–2014. If the mean is below 20,000 an economic region belongs to main group 2 for the entire sample period, i.e., 2001–2014.

former analysis is based on 32 observational units and the latter is based on 57 observational units. We conduct similar analyses for commuting.

The alternative specification calls for new specifications of what we have termed the 'outside' variables. For instance, for observational units in main regional group 2, the outside real hourly wage is now given as a weighted mean of real hourly wages in main regional group 1. The (time-varying) weight for an economic region in main regional group 1, is its population divided by the total population aged 20–64 years in main group 1. The same weights are utilized for the two other incentive variables, i.e., the unemployment rate and the employment share. The formulae are provided explicitly in Appendix E. The same is the case for the specification of the four sets of empirical equations to be estimated.

The detailed estimation results are provided in Appendix E. Before we compare the estimation results for the robustness analysis and the results for the main model, we notice that according to the results of the robustness analysis real wages does not seem to matter very much for internal (in- and out-) migration and commuting. One exception might be for persons with low educational achievement, a group with many immigrants.

The reason why wage income might matter less for internal migration in Norway than what is found in many other developed countries is due to more narrow wage differences. This is partly because of a relatively strong position of trade unions in the system of wage formation and in addition the relatively high share of employment in public sectors. That low educated people show relatively high migration response on wage incomes is partly due to high migration probabilities from peripheral to central regions among immigrants with refugee background (see e.g., Kornstad et al. 2017). The relatively low response on migration of wage incomes among high educated people must be seen in context with the fact that many high educated are already registered settled in the main regions when they finish their higher graduation. Many students involved in higher education register their in-migration to central regions before they fulfill their education, thus entering these regions with low or mostly intermediate education level.

To compare the estimation results from the robustness analysis and the estimation results in the main model we include four tables, which extract information from other tables in the article. In Tables 7 and 8, we compare, respectively, estimates of parameters related to internal in- and out-migration, whereas we in Tables 9 and 10 provide a corresponding comparison in conjunction with commuting. One should recall that whereas the estimates in the main specification are based on a system of eight regression equations for either internal migration or commuting, the estimates in the alternative specification are based on four equations since one either focus on in-migration from small to large economic regions or out-migration from small to large economic regions.

In Table 7, we compare estimates related to parameters in in-migration equations. Using the alternative specification, we are not able to obtain a positive estimate of the relative wage on internal in-migration. In fact, for the groups with low and high education the estimates are negative, although not significantly so at the 5 percent significance level. In the main specification, the relative wage enters positively for those with low education, and the estimate is almost significant at the 5 percent

significance level. For those with study-oriented upper secondary education, there is a significantly positive estimate of the relative wage variable in the main specification, whereas the effect is set to zero a priori in the new specification because of low significance in a preliminary estimation round. In contrast, the estimated effects of the relative unemployment variable are much stronger and more significant in the alternative than in the main specification. Whereas the effect of the relative unemployment variable is set to zero for both those with study-oriented upper secondary and high education in the main specification, there is a negative significant estimate consistent with our a priori assumptions in the alternative specification. When it comes to the relative employment share variable all the effects are set to zero both in the main and the alternative specification, because of low significance of this variable in a preliminary estimation round.

With respect to Table 8, we notice that in the alternative specification we have somewhat stronger effects of the relative wage variable on out-migration for those with low education. For the other three education categories, the effects are small and insignificant even though they are of the correct sign. They resemble to a large extent what was found for the main specification. The estimated effect of the relative unemployment rate for the alternative model is now significant for those with low education, whereas the effect was set to 0 in the main specification because the preliminary estimate had low significance. For the three other education categories the estimated effect is positive, but with a *t*-value just above 1. Thus, for those with study-oriented upper secondary education the estimated effect of the relative unemployment variable now turns out to be weaker than for the main specification, where it is almost significant at the 5 percent significance level. For the two remaining education categories, the effect of the relative unemployment rate is set to 0 in the main specification. When it comes to the relative employment share, we do not find a significant effect for any of the education categories using the alternative specification, whereas a significant negative estimate for those with low education is found using the main specification.

In this context, it might be important with a brief description of the Norwegian regional economic development during the period of investigation. Before the financial crisis in 2008, domestic movements went mainly toward the regions with the most vacant jobs, but this has changed after the financial crisis. International migration has in many ways compensated for the fact that internal population movements have followed more traditional paths, with net out-migration from several regions where employment has increased due to very high petroleum investments, especially in the western and south-western parts of Norway, but partly also in northern Norway (see e.g., Stambøl, 2017).

Next, we look at the results for in-commuting in Table 9. We find a positive and significant effect of the relative wage variable for those with low education using the alternative specification. The effect is also positive for the main model specification, but the estimate in the alternative model specification is three times as large as in the main model specification. For the three remaining groups all the effects are set to zero in the main model. The same is true for those with vocational education when considering the alternative model specification. Unfortunately, significant negative

Table 7 Effects of incentive variables on in-migration according to the main and the alternative specification

Variable	Education category	Main model specification[a]	Alternative model specification[b]
Relative real hourly wage	*LOW*	0.277	−0.683
		(1.839)	(−1.581)
	VOC	0[c]	0[c]
	SUS	0.609	0[c]
		(2.624)	
	HIGH	0[c]	−0.477
			(−1.663)
Relative unemployment rate	*LOW*	−0.044	−0.112
		(−1.618)	(−1.898)
	VOC	−0.029	−0.094
		(−1.528)	(−2.564)
	SUS	0[a]	−0.094[d]
	HIGH	0[c]	−0.094[d]
Relative employment share	*LOW*	0[c]	0[c]
	VOC	0[c]	0[c]
	SUS	0[c]	0[c]
	HIGH	0[c]	0[c]

[a]The results in this column correspond to those reported in the upper part of Table 1. Recall that they are based on a model specification containing eight equations, covering both in- and out-migration

[b]The results in this column correspond to those reported in Table 24 in Appendix E. Recall that they are based on a model specification containing four equations, covering only in-migration

[c]A priori restriction

[d]A priori equality restriction. The effects of the relative unemployment rate for *SUS* and *HIGH* are constrained to be as for *VOC*

Region-specific fixed effects and annual fixed effects are included in all equations. *t*-values in parenthesis are based on heteroskedasticity-consistent estimates of standard errors

estimates are obtained for those with study-oriented upper secondary and high education. This is contrary to what was expected.

The relative unemployment rate seems, generally, to enter stronger using the alternative model specification: For those with low and vocational education the estimates are larger in absolute value for the alternative model specification compared to the main model specification. In the main model specification, the effect of the relative unemployment rate for those with high education is set to zero. A negative estimate is obtained for the alternative model specification. Though, it is not significant at the 5 percent significance level. For those with study-oriented upper secondary education, the effect is set to zero for the alternative model

Table 8 Effects of incentive variables on out-migration according to the main and the alternative model specification

Variable	Education category	Main model specification[a]	Alternative model specification[b]
Relative real hourly wage	*LOW*	−0.118	−0.459
		(−1.776)	(−2.332)
	VOC	−0.118[c]	−0.129
			(−1.311)
	SUS	0[d]	−0.129[e]
	HIGH	−0.118[c]	−0.129[e]
Relative unemployment rate	*LOW*	0[d]	0.107
			(2.741)
	VOC	0[d]	0.017
			(1.169)
	SUS	0.037	0.017[f]
		(1.933)	
	HIGH	0[d]	0.017[f]
Relative employment share	*LOW*	−0.505	0[d]
		(−2.530)	
	VOC	0[d]	0[d]
	SUS	0[d]	0[d]
	HIGH	0[d]	0[d]

[a]The results in this column correspond to those reported in the lower part of Table 1. Recall that they are based on a model specification containing eight equations, covering both in- and out-migration

[b]The results in this column correspond to those reported in Table 25 in Appendix E. Recall that they are based on a model specification containing four equations, covering only out-migration

[c]A priori equality restriction. With respect to relative real hourly wage, the parameters for *VOC* and *HIGH* are constrained to be as for *LOW*

[d]A priori zero restriction

[e]A priori equality restriction. With respect to relative real hourly wage, the parameters for *SUS* and *HIGH* are constrained to be as for *VOC*

[f]A priori equality restriction. The effects of the relative unemployment rate for *SUS* and *HIGH* are constrained to be as for *VOC*

Region-specific fixed effects and annual fixed effects are included in all equations. *t*-values in parenthesis are based on heteroskedasticity-consistent estimates of standard errors

specification since the relative unemployment rate entered with little significance in a preliminary estimation round. For the main model specification, we obtain a negative estimate, but the *t*-value is only close to −1.

Table 9 Effects of incentive variables on in-commuting according to the main and the alternative specification

Variable	Education category	Main model specification[a]	Alternative model specification[b]
Relative real hourly wage	*LOW*	0.302	0.931
		(2.448)	(2.627)
	VOC	0[c]	0[c]
	SUS	0[c]	−1.385
			(−3.517)
	HIGH	0[c]	−0.672
			(−2.741)
Relative unemployment rate	*LOW*	−0.072	−0.130
		(−2.612)	(−2.823)
	VOC	−0.046	−0.193
		(−2.253)	(−6.340)
	SUS	−0.021	0[c]
		(−1.048)	
	HIGH	0[c]	−0.054
			(−1.637)
Relative employment share	*LOW*	0.505	0[c]
		(2.221)	
	VOC	0.813	0[c]
		(2.099)	
	SUS	0[c]	1.354
			(1.793)
	HIGH	0[c]	0[c]

[a]The results in this column correspond to those reported in the upper part of Table 4. Recall that they are based on a model specification containing eight equations, covering both in- and out-migration

[b]The results in this column correspond to those reported in Table 26 in Appendix E. Recall that they are based on a model specification containing four equations, covering only out-migration

[c]A priori zero restriction

Region-specific fixed effects and annual fixed effects are included in all equations. *t*-values in parenthesis are based on heteroskedasticity-consistent estimates of standard errors

The estimates of the effect of the relative employment share variable also differ between the two model specifications. For those with low and vocational education, we find no effects using the alternative specification, whereas positive and significant estimates are obtained using the main specification. In the main model specification, the effect for those with study-oriented upper education is set to zero. Using the alternative model specification, the estimate is positive and almost significant at the 5 percent significance level. For those with high education, the effect is set to zero for both model specifications.

Table 10 Effects of incentive variables on out-commuting according to the main and the alternative model specification

Variable	Education category	Main model specification[a]	Alternative model specification[b]
Relative real hourly wage	*LOW*	0[c]	0[c]
	VOC	0[c]	0[c]
	SUS	−0.183	0[c]
		(−1.907)	
	HIGH	−0.157	0[c]
		(−3.108)	
Relative unemployment rate	*LOW*	0[c]	0.063
			(2.003)
	VOC	0[c]	−0.035
			(−1.788)
	SUS	0.019	0[c]
		(1.381)	
	HIGH	0[c]	0[c]
Relative employment share	*LOW*	0[c]	0.716
			(2.515)
	VOC	0[c]	−1.413
			(−2.441)
	SUS	−0.294	−0.667
		(−1.634)	(−2.720)
	HIGH	−0.592	−1.521
		(−2.375)	(−3.436)

[a]The results in this column correspond to those reported in the upper part of Table 4. Recall that they are based on a model specification containing eight equations, covering both in- and out-migration

[b]The results in this column correspond to those reported in Table 27 in Appendix E. Recall that they are based on a model specification containing four equations, covering only out-migration

[c]A priori zero restriction

Region-specific fixed effects and annual fixed effects are included in all equations. *t*-values in parenthesis are based on heteroskedasticity-consistent estimates of standard errors

Turning now to out-commuting, we are, as seen from Table 10, unable to find any significant effects for the relative wage variable using the alternative specification. In contrast, the variable entered with a significant negative effect for those with high education and almost a significant effect for those with study-oriented upper secondary education using the main model specification.

The estimated effects of the relative unemployment rate also differ somewhat. Using the alternative model, we have a positive and significant effect for those with low education whereas the effect is zero according to the main model. For

those with vocational education, we have wrong sign for the alternative model, but the estimate is not significant at the 5 percent significance level. For the two remaining education groups, we find no effect of the relative unemployment rate using the alternative model specification. For the main model, we do not find any significant effects. For those with study-oriented upper secondary education, we have a positive estimate, but with a *t*-value below 1.4.

Using the alternative specification, we find significant negative effects of relative employment shares on out-commuting for all the educational groups except for those with low education, where we find a significant positive estimate. In the main specification, we also have negative estimates for those with study-oriented upper secondary and high education, but the estimates are smaller in absolute values and less significant compared to those obtain for the alternative model specification. For those with low and vocational education, the effect of the relative employment share was set to zero a priori in the main model.

A summarize of our findings is then that classic economic internal migration motives as studied in for instance Sjaastad (1962) seem to matter modestly in Norway. In contrast, labor market conditions seem to matter more for migration and commuting than real wages. However, real wages and unemployment are insufficient for fully explaining internal migration and commuting. Other additional factors are needed. Recent research favors amenities, e.g., culture, landscape, public service, public infrastructure, climate, crime and social/family motives as main reasons for internal migration (see e.g., Chen and Rosenthal 2008; Niedomysl 2011; Niedomysl and Clark 2014; Korpi and Clark 2015).

8 Conclusions

Employing data for economic regions in Norway, we used panel data SUR models to analyze the extent to which internal migration and commuting activity are influenced by incentive variables. Our model is disaggregated in the educational dimension in that we consider four different educational groups. Sixteen flow variables played the part of response variables. For both internal migration and commuting, we looked at both inflow and outflow. For a given educational group, the explanatory variables are common to both response variables. In many cases, we do not find significant effects of the explanatory variables. Generally, the group with the lowest education appears to be the most sensitive with respect to the incentive variables. When we consider migration inflow, we find a significant positive effect of the relative wage variable for the group with study-oriented upper secondary education, and a positive almost significant estimate for those with low education. In the case of migration outflow the groups with low, vocational and high education are somewhat influenced by relative wages. For in-commuting, we only find a relative wage variable effect on the group with low education. When out-commuting is considered, significant and nearly significant effects are found for two of the groups, i.e., for those with study-oriented upper secondary and high education. In all cases where we found at least some effect, the signs are in accordance with a priori expectations.

For the groups with low and vocational education, an increase in a region's relative unemployment rate leads to somewhat lower in-migration. In contrast, we find no effect for out-migration. For the groups with study-oriented secondary education and high education, we find no effect on the relative unemployment rate on in-migration, but with respect to the former group we find a positive and almost significant effect on out-migration.

We find that an increase in the relative unemployment rate leads to significantly lower in-commuting for the groups with low and vocational education. For both groups, we fail to find any effect on out-commuting. For the group with high education we find no effect of the relative unemployment rate on neither in- nor out-commuting. Lastly, for those with study-oriented education we find a positive insignificant effect of the relative unemployment rate on out-commuting, but no effect on in-commuting.

Also, the relative employment share variable seems to enter with the expected sign in the case where the companion estimate is of some significance. With respect to in-migration, we find no effect of this variable for any of the education types, but we find a significant negative effect for those with low education in connection with out-migration. With respect to in-commuting, we find significant positive effects for those with low and vocational education. However, out-commuting is unaffected. For the two other education types one has the opposite situation, that is in-commuting is unaffected, but out-commuting is affected negatively, and significantly so for those with high education.

Our robustness analysis, which focused on internal migration and commuting from 'small' to 'large' economic regions produced a somewhat variegated picture. Whereas the relative unemployment variables generally entered more forcefully in specifications underlying the robustness analysis than in the main cases, it turned out to be harder to obtain large and significant estimates with the expected sign for the relative wage variables.

By considering the results from both the main model and the robustness analysis, we conclude that the incentive variables do not fully capture all motives for internal migration and commuting. Ideally, our modeling framework would benefit from the inclusion of variables related to amenities. Unfortunately, most of such variables are not included in registry data sets available to researchers.

In addition to the incentive variables and the population size of the region, we included regional fixed effects as well as annual fixed effects. Thus, our econometric framework is simpler than the approach based on pair-wise observations used by other researchers in this area. This more sophisticated approach, in the tradition of gravity models, is characterized by including population variables and fixed effects for both the 'sending' and the 'receiving' economic region. One challenge associated with this approach, when there are many observational units, is the predominance of zeros. Dropping observation pairs with zeros may have an undesirable effect on the inference. Researchers have recently started to employ a model that uses maximum likelihood estimation based on the Poisson distribution which also accounts for the zero observations (see Santos Silva and Tenreyro 2006). However, in this approach the response variables cannot be log-transformed, as we have done in our analysis.[9] It is an interesting topic for further analysis, nevertheless.

[9] Abstracting from the problem with zeros, the log-transformation is believed to generate a more well-behaved model specification than models based on untransformed variables.

We did not take differences in age and gender into account when modeling internal migration and commuting flows.[10] Such variables seem more relevant in a microeconometric setting. Since the time span is somewhat limited, the age and gender distribution will remain relatively stable through the period.

We heave disregarded the impact of variation in housing prices across the observational units.[11] The regional housing price data do not fit well with our regional classification since they focus on areas where the turnover is of some size. For contributions emphasizing the explanatory power of housing prices for internal mobility, see Cannari et al. (2000) and Hämäläinen and Böckerman (2004). Another issue related to housing is that home ownership is widespread in Norway. The rental market is quite limited and is primarily restricted to the largest cities. Palomares and van Ham (2020) noted that home ownership was an important factor for limiting internal mobility in Spain, and it is possible that high levels of home ownership in Norway may also work to lower migration propensities in Norway.

Another issue that we have not considered in this article is the distinction between international immigrants and individuals born in Norway when it comes to internal migration in Norway. Individuals born abroad (immigrants) are believed to follow a pattern that differs from that of individuals born in Norway. This issue has also been raised by other researchers with respect to other countries, see for instance Schündeln (2014). Another issue that has been addressed is whether there is any response by natives to internal migration of international immigrants, see for instance Kritz and Gurak (2001) and Ali et al. (2012).

In summary, we find overall weak responses to the incentive variables employed in this study. There is, however, some interesting variation across educational levels. The lowest educated appears to be most responsive. Because of increased educational attainment in the population, there will be still fewer individuals in this group, which is dominated by immigrants. According to our model and empirical results this will impair the government's possibility to influence internal migration by measures impacting the two incentive variables. Said in another way, the stimuli will need to be stronger to maintain the same effect as when there are more individuals in this group.

Appendix

Appendix A. Definition of symbols

See Table 11.

[10] Carlsen et al. (2013) found that the response in internal migration rates to local unemployment shocks was larger in absolute value among the population aged 25–40 years than the population aged 41–66 years, and especially for those with tertiary education.

[11] The regional fixed effects will reflect the effects of differences in price levels between the regional units, but not changes in relative housing prices over time. Carlsen et al. (2013), which is an earlier study on Norwegian data at mainly the same regional classification as used in this article, utilized house transaction data to account for time-varying regional differences in costs of living.

Table 11 List of variables

Variable	Description
$MIG_{it}^{IN,\ LOW}$	Inflow (migration) of persons with low education to region *i* from other internal regions in year *t*
$MIG_{it}^{IN,\ VOC}$	Inflow (migration) of persons with vocational education to region *i* from other internal regions in year *t*
$MIG_{it}^{IN,\ SUS}$	Inflow (migration) of persons with study-oriented upper secondary education to region *i* from other internal regions in year *t*
$MIG_{it}^{IN,\ HIGH}$	Inflow (migration) of persons with high education to region *i* from other internal regions in year *t*
$MIG_{it}^{OUT,\ LOW}$	Outflow (migration) of persons with low education from region *i* to other internal regions in year *t*
$MIG_{it}^{OUT,\ VOC}$	Outflow of persons (migration) with vocational education from region *i* to other internal regions in year *t*
$MIG_{it}^{OUT,\ SUS}$	Outflow of persons (migration) with study-oriented upper secondary education from region *i* to other internal regions in year *t*
$MIG_{it}^{OUT,\ HIGH}$	Outflow of persons (migration) with high education from region *i* to other internal regions in year *t*
$COM_{it}^{IN,\ LOW}$	Inflow of commuting workers with low education to region *i* from other internal regions in year *t*
$COM_{it}^{IN,\ VOC}$	Inflow of commuting workers with vocational education to region *i* from other internal regions in year *t*
$COM_{it}^{IN,\ SUS}$	Inflow of commuting workers with study-oriented upper secondary education to region *i* from other internal regions in year *t*
$COM_{it}^{IN,\ HIGH}$	Inflow of commuting workers with high education to region *i* from other internal regions in year *t*
$COM_{it}^{OUT,\ LOW}$	Outflow of commuting workers with low education to region *i* from other internal regions in year *t*
$COM_{it}^{OUT,\ VOC}$	Outflow of commuting workers with vocational education to region *i* from other internal regions in year *t*
$COM_{it}^{OUT,\ SUS}$	Outflow of commuting workers with study-oriented upper secondary education to region *i* from other internal regions in year *t*
$COM_{it}^{OUT,\ HIGH}$	Outflow of commuting workers with low education to region *i* from other internal regions in year *t*
POP_{it}^{LOW}	Size of the population of age 15–74 years in region *i* and year *t* with low education
POP_{it}^{VOC}	Size of the population of age 15–74 years in region *i* and year *t* with vocational education
POP_{it}^{SUS}	Size of the population of age 15–74 years in region *i* and year *t* with study- oriented upper secondary education
POP_{it}^{HIGH}	Size of the population of age 15–74 years in region *i* and year *t* with high education
$RHWAGE_{it}^{LOW}$	Real mean average hourly wage in region *i* in year *t* among those with low education
$RHWAGEOTH_{it}^{LOW}$	Weighted real mean average hourly wage outside region *i* in year *t* among those with loweducation
$RHWAGE_{it}^{VOC}$	Real mean average hourly wage in region *i* in year *t* among those with vocational education

Table 11 (continued)

Variable	Description
$RHWAGEOTH_{it}^{VOC}$	Weighted real mean average hourly wage outside region i in year t among those with vocational education
$RHWAGE_{it}^{SUS}$	Real mean average hourly wage in region i in year t among those with study-oriented upper secondary education
$RHWAGEOTH_{it}^{SUS}$	Weighted real mean average hourly wage outside region i in year t among those with study-oriented upper secondary education
$RHWAGE_{it}^{HIGH}$	Real mean average hourly wage in region i in year t among those with study-oriented upper secondary education
$RHWAGEOTH_{it}^{HIGH}$	Weighted real mean average hourly wage outside region i in year t among those with study-oriented upper secondary education
UR_{it}^{LOW}	Unemployment rate in region i in year t among those with low education
$UROTH_{it}^{LOW}$	Weighted unemployment rate across other regions than i in year t among those with low education
UR_{it}^{VOC}	Unemployment rate in region i in year t among those with vocational education
$UROTH_{it}^{VOC}$	Weighted unemployment rate across other regions than i in year t among those with vocational education
UR_{it}^{SUS}	Unemployment rate in region i in year t among those with study-oriented upper secondary education
$UROTH_{it}^{SUS}$	Weighted unemployment rate across other regions than i in year t among those with study-oriented upper secondary education
UR_{it}^{HIGH}	Unemployment rate in region i in year t among those with high education
$UROTH_{it}^{HIGH}$	Weighted unemployment rate across other regions than i in year t among those with high education
$EMPSHARE_{it}^{LOW}$	Employment share of those with low education in region i in year t
$EMPSHAREOTH_{it}^{LOW}$	Weighted employment share of those with low education outside region i in year t
$EMPSHARE_{it}^{VOC}$	Employment share of those with vocational education in region i in year t
$EMPSHAREOTH_{it}^{VOC}$	Weighted employment share of those with vocational education outside region i in year t
$EMPSHARE_{it}^{SUS}$	Employment share of those with study-oriented upper secondary education in region i in year t
$EMPSHAREOTH_{it}^{SUS}$	Weighted employment share of those with study-oriented upper secondary education outside region i in year t
$EMPSHARE_{it}^{HIGH}$	Employment share of those with high education in region i in year t
$EMPSHAREOTH_{it}^{HIGH}$	Weighted employment share of those with high education outside region i in year t

Appendix B. Economic regions

See Table 12.

Table 12 An overview of the economic regions

Economic region	County	Region number	Main group	Current region
Halden	Østfold	0191	2	1
Moss	Østfold	0192	1	2
Fredrikstad/Sarpsborg	Østfold	0193	1	3
Askim/Mysen	Østfold	0194	1	4
Follo	Akershus	0291	1	5
Bærum/Asker	Akershus	0292	1	6
Lillestrøm	Akershus	0293	1	7
Ullensaker/Eidsvoll	Akershus	0294	1	8
Oslo	Oslo	0391	1	9
Kongsvinger	Hedmark	0491	1	10
Hamar	Hedmark	0492	1	11
Elverum	Hedmark	0493	1	12
Tynset	Hedmark	0494	2	13
Lillehammer	Oppland	0591	1	14
Gjøvik	Oppland	0592	1	15
Midt-Gudbrandsdalen	Oppland	0593	2	16
Nord-Gudbrandsdalen	Oppland	0594	2	17
Hadeland	Oppland	0595	2	18
Valdres	Oppland	0596	2	19
Drammen	Buskerud	0691	1	20
Kongsberg	Buskerud	0692	2	21
Hønefoss	Buskerud	0693	1	22
Hallingdal	Buskerud	0694	2	23
Tønsberg/Horten	Vestfold	0791	1	24
Holmestrand	Vestfold	0792	2	25
Sandefjord/Larvik	Vestfold	0793	1	26
Sande/Svelvik	Vestfold	0794	2	27
Skien/Porsgrunn	Telemark	0891	1	28
Notodden/Bø	Telemark	0892	2	29
Kragerø	Telemark	0893	2	30
Rjukan	Telemark	0894	2	31
Vest-Telemark	Telemark	0895	2	32
Risør	Aust-Agder	0991	2	33
Arendal	Aust-Agder	0992	1	34
Lillesand	Aust-Agder	0993	2	35
Setesdal	Aust-Agder	0994	2	36
Kristiansand	Vest-Agder	1091	1	37
Mandal	Vest-Agder	1092	2	38
Lyngdal/Farsund	Vest-Agder	1093	2	39
Flekkefjord	Vest-Agder	1094	2	40
Egersund	Rogaland	1191	2	41
Stavanger/Sandnes	Rogaland	1192	1	42

Table 12 (continued)

Economic region	County	Region number	Main group	Current region
Haugesund	Rogaland	1193	1	43
Jæren	Rogaland	1194	1	44
Bergen	Hordaland	1291	1	45
Odda	Hordaland	1294	2	46
Voss	Hordaland	1295	2	47
Sunnhordland	Hordaland	1296	1	48
Florø	Sogn og Fjordane	1491	2	49
Høyanger	Sogn og Fjordane	1492	2	50
Sogndal/Årdal	Sogn og Fjordane	1493	2	51
Førde	Sogn og Fjordane	1494	2	52
Nordfjord	Sogn og Fjordane	1495	2	53
Molde	Møre og Romsdal	1591	1	54
Kristiansund	Møre og Romsdal	1592	1	55
Ålesund	Møre og Romsdal	1593	1	56
Ullsteinvik	Møre og Romsdal	1594	2	57
Ørsta/Volda	Møre og Romsdal	1595	2	58
Sunndalsøra	Møre og Romsdal	1596	2	59
Surnadal	Møre og Romsdal	1597	2	60
Trondheim	Sør-Trøndelag	1691	1	61
Frøya/Hitra	Sør-Trøndelag	1692	2	62
Brekstad	Sør-Trøndelag	1693	2	63
Oppdal	Sør-Trøndelag	1694	2	64
Orkanger	Sør-Trøndelag	1695	2	65
Røros	Sør-Trøndelag	1696	2	66
Steinkjer	Nord-Trøndelag	1791	1	67
Namsos	Nord-Trøndelag	1792	2	68
Stjørdalshalsen	Nord-Trøndelag	1793	2	69
Levanger/Verdalsøra	Nord-Trøndelag	1794	2	70
Grong	Nord-Trøndelag	1795	2	71
Rørvik	Nord-Trøndelag	1796	2	72
Bodø	Nordland	1891	1	73
Narvik	Nordland	1892	2	74
Brønnøysund	Nordland	1893	2	75
Sandnessjøen	Nordland	1894	2	76
Mosjøen	Nordland	1895	2	77
Mo i Rana	Nordland	1896	2	78
Lofoten	Nordland	1897	2	79
Vesterålen	Nordland	1898	2	80
Harstad	Troms	1991	2	81
Tromsø	Troms	1992	1	82
Andselv	Troms	1993	2	83
Finnsnes	Troms	1994	2	84

Table 12 (continued)

Economic region	County	Region number	Main group	Current region
Nord-Troms	Troms	1995	2	85
Vadsø	Finnmark	2091	2	86
Hammerfest	Finnmark	2092	2	87
Alta	Finnmark	2093	2	88
Kirkenes	Finnmark	2094	2	89

Appendix C. Classification of education

See Table 13.

Table 13 Educational groups

Own codes	Description	Classification numbers of education	English abbreviations used in this article
1	Compulsory education	0,1,2	*LOW*
2	Study-oriented upper secondary education	30, 315, 368, 40, 415, 468, 34, 44, 50, 54	*SUS*
3	Vocational education	3, 4, 5 (except for codes mentioned above)	*VOC*
4	First stage of higher education, undergraduate level	6	*HIGH*
4	Second stage of higher education (post- graduate education)	7, 8	*HIGH*
5	Unspecified/Unknown	9	

Appendix D. Measures of dispersion across observational units

Tables 14, 15 show annual coefficients of variation for real hourly wage and unemployment rate and Tables 16, 17, 18, 19, 20, 21, 22, 23 show Spearman correlation coefficients for real hourly wage and unemployment rate for different education groups.

Table 14 Annual coefficients of variation for the real hourly wage variable

Year	Type of education			
	LOW	*VOC*	*SUS*	*HIGH*
2001	0.071	0.076	0.082	0.084
2002	0.065	0.079	0.080	0.082
2003	0.064	0.081	0.081	0.097
2004	0.077	0.089	0.094	0.123
2005	0.061	0.070	0.081	0.104
2006	0.068	0.075	0.086	0.106
2007	0.065	0.078	0.088	0.115
2008	0.063	0.079	0.085	0.117
2009	0.065	0.086	0.089	0.123
2010	0.073	0.084	0.087	0.121
2011	0.059	0.076	0.084	0.112
2012	0.057	0.075	0.086	0.110
2013	0.060	0.076	0.086	0.110
2014	0.063	0.080	0.082	0.107

Table 15 Annual coefficients of variation for the unemployment rate variable

Year	Type of education			
	LOW	*VOC*	*SUS*	*HIGH*
2001	0.358	0.457	0.382	0.361
2002	0.326	0.404	0.356	0.337
2003	0.300	0.348	0.312	0.306
2004	0.293	0.356	0.286	0.324
2005	0.281	0.330	0.283	0.301
2006	0.284	0.354	0.302	0.295
2007	0.318	0.372	0.333	0.327
2008	0.321	0.395	0.327	0.331
2009	0.294	0.354	0.343	0.315
2010	0.283	0.288	0.279	0.261
2011	0.300	0.311	0.286	0.272
2012	0.311	0.304	0.268	0.266
2013	0.319	0.333	0.299	0.279
2014	0.322	0.337	0.289	0.269

Table 16 Spearman correlation coefficients of mean real hourly wage. Individuals with low education

	Year													
Year	'01	'02	'03	'04	'05	'06	'07	'08	'09	'10	'11	'12	'13	'14
'01	1.00													
'02	0.88	1.00												
'03	0.85	0.89	1.00											
'04	0.85	0.87	0.91	1.00										
'05	0.84	0.87	0.86	0.93	1.00									
'06	0.82	0.84	0.86	0.90	0.92	1.00								
'07	0.81	0.80	0.82	0.89	0.87	0.89	1.00							
'08	0.76	0.73	0.76	0.80	0.80	0.83	0.89	1.00						
'09	0.74	0.77	0.75	0.78	0.79	0.80	0.84	0.93	1.00					
'10	0.76	0.77	0.78	0.80	0.79	0.79	0.89	0.89	0.93	1.00				
'11	0.75	0.73	0.77	0.76	0.72	0.74	0.85	0.85	0.84	0.89	1.00			
'12	0.73	0.71	0.76	0.76	0.73	0.72	0.80	0.81	0.84	0.87	0.92	1.00		
'13	0.71	0.66	0.72	0.75	0.72	0.71	0.82	0.84	0.84	0.84	0.89	0.93	1.00	
'14	0.71	0.68	0.73	0.74	0.71	0.74	0.82	0.81	0.83	0.87	0.88	0.93	0.92	1.00

Table 17 Spearman correlation coefficients of unemployment rate. Individuals with low education

	Year													
Year	'01	'02	'03	'04	'05	'06	'07	'08	'09	'10	'11	'12	'13	'14
'01	1.00													
'02	0.94	1.00												
'03	0.88	0.90	1.00											
'04	0.81	0.84	0.87	1.00										
'05	0.73	0.77	0.77	0.90	1.00									
'06	0.75	0.78	0.77	0.80	0.88	1.00								
'07	0.64	0.70	0.70	0.76	0.82	0.87	1.00							
'08	0.69	0.71	0.73	0.73	0.77	0.84	0.88	1.00						
'09	0.73	0.74	0.75	0.74	0.77	0.82	0.83	0.91	1.00					
'10	0.51	0.52	0.58	0.63	0.60	0.63	0.66	0.76	0.79	1.00				
'11	0.50	0.54	0.59	0.66	0.65	0.69	0.77	0.81	0.82	0.87	1.00			
'12	0.52	0.52	0.57	0.60	0.61	0.70	0.75	0.82	0.81	0.79	0.93	1.00		
'13	0.52	0.51	0.54	0.61	0.61	0.70	0.76	0.81	0.80	0.78	0.89	0.95	1.00	
'14	0.52	0.51	0.59	0.64	0.67	0.74	0.76	0.83	0.82	0.79	0.86	0.90	0.92	1.00

Table 18 Spearman correlation coefficients of mean real hourly wage. Individuals with vocational education

	Year													
Year	‘01	‘02	‘03	‘04	‘05	‘06	‘07	‘08	‘09	‘10	‘11	‘12	‘13	‘14
‘01	1.00													
‘02	0.87	1.00												
‘03	0.87	0.96	1.00											
‘04	0.84	0.87	0.89	1.00										
‘05	0.85	0.88	0.93	0.92	1.00									
‘06	0.84	0.87	0.91	0.92	0.97	1.00								
‘07	0.83	0.87	0.92	0.91	0.96	0.97	1.00							
‘08	0.87	0.83	0.87	0.87	0.92	0.91	0.95	1.00						
‘09	0.81	0.87	0.89	0.87	0.92	0.92	0.95	0.94	1.00					
‘10	0.78	0.83	0.88	0.85	0.91	0.90	0.94	0.92	0.96	1.00				
‘11	0.78	0.83	0.87	0.81	0.87	0.85	0.90	0.89	0.94	0.96	1.00			
‘12	0.75	0.81	0.84	0.79	0.86	0.85	0.87	0.87	0.93	0.93	0.96	1.00		
‘13	0.73	0.77	0.82	0.77	0.84	0.83	0.87	0.86	0.92	0.93	0.95	0.97	1.00	
‘14	0.75	0.78	0.82	0.81	0.85	0.85	0.89	0.89	0.94	0.94	0.96	0.96	0.97	1.00

Table 19 Spearman correlation coefficients of unemployment rates. Individuals with vocational education

	Year													
Year	‘01	‘02	‘03	‘04	‘05	‘06	‘07	‘08	‘09	‘10	‘11	‘12	‘13	‘14
‘01	1.00													
‘02	0.93	1.00												
‘03	0.83	0.85	1.00											
‘04	0.80	0.80	0.82	1.00										
‘05	0.62	0.68	0.69	0.80	1.00									
‘06	0.61	0.69	0.66	0.70	0.89	1.00								
‘07	0.57	0.66	0.62	0.65	0.76	0.90	1.00							
‘08	0.52	0.62	0.59	0.59	0.71	0.81	0.90	1.00						
‘09	0.47	0.57	0.55	0.51	0.64	0.75	0.82	0.84	1.00					
‘10	0.34	0.38	0.38	0.38	0.48	0.60	0.65	0.64	0.80	1.00				
‘11	0.38	0.42	0.41	0.50	0.58	0.61	0.62	0.57	0.66	0.80	1.00			
‘12	0.33	0.41	0.38	0.49	0.59	0.66	0.64	0.58	0.67	0.69	0.83	1.00		
‘13	0.27	0.36	0.34	0.43	0.54	0.67	0.70	0.65	0.72	0.74	0.77	0.90	1.00	
‘14	0.23	0.34	0.30	0.41	0.52	0.63	0.67	0.62	0.70	0.70	0.68	0.83	0.85	1.00

Table 20 Spearman correlation coefficients of mean real hourly wage. Individuals with study-oriented upper secondary education

	Year													
Year	'01	'02	'03	'04	'05	'06	'07	'08	'09	'10	'11	'12	'13	'14
'01	1.00													
'02	0.87	1.00												
'03	0.86	0.95	1.00											
'04	0.84	0.86	0.91	1.00										
'05	0.87	0.89	0.93	0.92	1.00									
'06	0.85	0.86	0.91	0.89	0.94	1.00								
'07	0.83	0.86	0.91	0.87	0.93	0.95	1.00							
'08	0.87	0.89	0.92	0.89	0.91	0.92	0.95	1.00						
'09	0.83	0.86	0.87	0.87	0.89	0.91	0.94	0.95	1.00					
'10	0.87	0.84	0.87	0.86	0.87	0.88	0.90	0.91	0.91	1.00				
'11	0.82	0.84	0.89	0.85	0.89	0.90	0.93	0.93	0.95	0.92	1.00			
'12	0.80	0.84	0.90	0.85	0.87	0.88	0.91	0.91	0.92	0.90	0.95	1.00		
'13	0.81	0.87	0.90	0.84	0.87	0.88	0.90	0.93	0.93	0.90	0.95	0.96	1.00	
'14	0.81	0.87	0.89	0.85	0.86	0.87	0.88	0.92	0.91	0.89	0.93	0.94	0.97	1.00

Table 21 Spearman correlation coefficients of unemployment rates. Individuals with study-oriented upper secondary education

	Year													
Year	'01	'02	'03	'04	'05	'06	'07	'08	'09	'10	'11	'12	'13	'14
'01	1.00													
'02	0.89	1.00												
'03	0.82	0.87	1.00											
'04	0.73	0.74	0.82	1.00										
'05	0.63	0.62	0.63	0.79	1.00									
'06	0.73	0.66	0.67	0.76	0.83	1.00								
'07	0.68	0.59	0.58	0.68	0.78	0.83	1.00							
'08	0.69	0.60	0.61	0.60	0.60	0.71	0.79	1.00						
'09	0.62	0.62	0.59	0.55	0.59	0.64	0.69	0.73	1.00					
'10	0.48	0.50	0.46	0.51	0.50	0.54	0.56	0.65	0.71	1.00				
'11	0.42	0.45	0.43	0.48	0.53	0.58	0.63	0.61	0.62	0.78	1.00			
'12	0.41	0.40	0.43	0.48	0.55	0.56	0.65	0.61	0.62	0.65	0.78	1.00		
'13	0.33	0.36	0.37	0.41	0.44	0.55	0.55	0.53	0.59	0.65	0.74	0.75	1.00	
'14	0.30	0.28	0.34	0.52	0.53	0.55	0.60	0.54	0.57	0.66	0.65	0.69	0.75	1.00

Table 22 Spearman correlation coefficients of mean real hourly wage. Individuals with high education

	Year													
Year	‘01	‘02	‘03	‘04	‘05	‘06	‘07	‘08	‘09	‘10	‘11	‘12	‘13	‘14
‘01	1.00													
‘02	0.74	1.00												
‘03	0.80	0.76	1.00											
‘04	0.70	0.44	0.80	1.00										
‘05	0.78	0.54	0.81	0.84	1.00									
‘06	0.78	0.59	0.81	0.82	0.92	1.00								
‘07	0.78	0.66	0.87	0.80	0.87	0.92	1.00							
‘08	0.84	0.69	0.86	0.80	0.89	0.89	0.92	1.00						
‘09	0.82	0.70	0.88	0.81	0.88	0.87	0.91	0.96	1.00					
‘10	0.80	0.69	0.85	0.78	0.83	0.86	0.89	0.93	0.95	1.00				
‘11	0.83	0.76	0.87	0.75	0.84	0.86	0.91	0.94	0.95	0.93	1.00			
‘12	0.82	0.75	0.89	0.75	0.85	0.84	0.92	0.95	0.95	0.92	0.96	1.00		
‘13	0.81	0.72	0.85	0.74	0.82	0.83	0.89	0.92	0.94	0.92	0.95	0.96	1.00	
‘14	0.80	0.73	0.87	0.79	0.83	0.83	0.89	0.93	0.94	0.92	0.93	0.95	0.96	1.00

Table 23 Spearman correlation coefficients of unemployment rates. Individuals with high education

	Year													
Year	‘01	‘02	‘03	‘04	‘05	‘06	‘07	‘08	‘09	‘10	‘11	‘12	‘13	‘14
‘01	1.00													
‘02	0.68	1.00												
‘03	0.62	0.73	1.00											
‘04	0.73	0.64	0.81	1.00										
‘05	0.58	0.55	0.76	0.85	1.00									
‘06	0.61	0.58	0.66	0.74	0.72	1.00								
‘07	0.54	0.54	0.62	0.66	0.64	0.73	1.00							
‘08	0.50	0.54	0.52	0.60	0.58	0.70	0.76	1.00						
‘09	0.37	0.56	0.53	0.45	0.56	0.56	0.57	0.72	1.00					
‘10	0.43	0.47	0.61	0.66	0.67	0.61	0.60	0.69	0.65	1.00				
‘11	0.36	0.37	0.53	0.54	0.55	0.48	0.54	0.54	0.41	0.77	1.00			
‘12	0.31	0.39	0.46	0.49	0.46	0.37	0.38	0.45	0.48	0.65	0.74	1.00		
‘13	0.20	0.30	0.44	0.40	0.44	0.36	0.39	0.43	0.40	0.67	0.73	0.72	1.00	
‘14	0.26	0.23	0.43	0.43	0.49	0.42	0.40	0.42	0.40	0.62	0.63	0.61	0.80	1.00

Appendix E. Detailed results for the robustness analysis

In this appendix, we concentrate on internal migration and commuting from small to large economic regions. We divide the economic regions into two groups, referred to as group 1 and group 2.

Table 24 Internal in-migration to economic regions in group 1 from group 2. Iterative SUR-estimates

Left-hand variable	Parameter	Type of variable	Estimate	*t*-value
$\log(MIG1_{it}^{IN,\ LOW})$	$\beta 1^{M,IN,\ LOW}$	Population	0.518	2.130
	$\gamma 1^{M,IN,\ LOW}$	Unemployment	−0.112	−1.898
	$\theta 1^{M,IN,\ LOW}$	Real wage	−0.683	−1.581
	$\eta 1^{M,IN,\ LOW}$	Employment share	0[a]	
$\log(MIG1_{it}^{IN,\ VOC})$	$\beta 1^{M,IN,\ VOC}$	Population	0.691	2.678
	$\gamma 1^{M,IN,\ VOC}$	Unemployment	−0.094	−2.564
	$\theta 1^{M,IN,\ VOC}$	Real wage	0[a]	
	$\eta 1^{M,IN,\ VOC}$	Employment share	−1.652	−1.334
$\log(MIG1_{it}^{IN,\ SUS})$	$\beta 1^{M,IN,\ SUS}$	Population	0.267	0.817
	$\gamma 1^{M,IN,\ SUS}$	Unemployment	−0.094[b]	
	$\theta 1^{M,IN,\ SUS}$	Real wage	0[a]	
	$\eta 1^{M,IN,\ SUS}$	Employment share	0[a]	
$\log(MIG1_{it}^{IN,\ HIGH})$	$\beta 1^{M,IN,\ HIGH}$	Population	0.964	4.583
	$\gamma 1^{M,IN,\ HIGH}$	Unemployment	−0.094[b]	
	$\theta 1^{M,IN,\ HIGH}$	Real wage	−0.477	−1.663
	$\eta 1^{M,IN,HIGH}$	Employment share	0[a]	

The number of observations is 416.The standard errors of regression are 0.133, 0.158, 0.178 and 0.141 for *LOW*, *VOC*, *SUS* and *HIGH*, respectively

[a]A priori zero restriction

[b]A priori restrictions$\gamma 1^{M,IN,\ VOC} = \gamma 1^{M,IN,\ SUS} = \gamma 1^{M,IN,HIGH}$

The largest economic regions are in group 1, and the smallest economic regions are in group 2. The number of economic regions in groups 1 and 2 are 32 and 57, respectively. We need to define some new sets. Let R_1 and R_2 contain, respectively, the economic regions that belong to main group 1 and 2.

As new response variables we now have $\log(MIG1_{it}^{IN,e})$, $\log(COM1_{it}^{IN,e})$; $i \in R_1$ and $\log(MIG2_{jt}^{OUT,e})$, $\log(COM2_{jt}^{OUT,e})$; $j \in R_2$; $e = \{LOW,\ VOC,\ SUS,\ HIGH\}$. $MIG1_{it}^{IN,e}$ denotes the internal in-migration to region i in group 1 from group 2 and $COM1_{it}^{IN,e}$ denotes the internal in-commuting to region i in group 1 from group 2 by those with education of type e. Furthermore, $MIG2_{jt}^{OUT,e}$ denotes the internal out-migration of people with education of type e from economic region i in group 2 to group 1 and $COM2_{jt}^{OUT,e}$ denotes the out-commuting of people with education e from economic region j in group 2 to group 1.

We now operationalize the concept of 'outside' values of the incentive variables in another way than under the main alternative and define the following variables:

$$RHWAGEOTH1_t^e = \frac{\sum_{i \in R_1} POP_{jt}^e \times RHWAGE_{it}^e}{\sum_{i \in R_1} POP_{it}^e}; e = \{LOW,\ VOC,\ SUS,\ HIGH\}, \tag{7}$$

Table 25 Internal out-migration from economic regions in group 2 to group 1. Iterative SUR-estimates

Left-hand variable	Parameter	Type of variable	Estimate	*t*-value
$\log(MIG2_{jt}^{OUT,\ LOW})$	$\beta 2^{M,OUT,\ LOW}$	Population	1.084	24.202
	$\gamma 2^{M,OUT,\ LOW}$	Unemployment	0.107	2.741
	$\theta 2^{M,OUT,\ LOW}$	Real wage	−0.459	−2.332
	$\eta 2^{M,OUT,\ LOW}$	Employment share	0[a]	
$\log(MIG2_{jt}^{OUT,\ VOC})$	$\beta 2^{M,OUT,\ VOC}$	Population	1.163	10.708
	$\gamma 2^{M,OUT,\ VOC}$	Unemployment	0.017	1.169
	$\theta 2^{M,OUT,\ VOC}$	Real wage	−0.129	−1.311
	$\eta 2^{M,OUT,\ VOC}$	Employment share	0[a]	
$\log(MIG2_{jt}^{OUT,\ SUS})$	$\beta 2^{M,OUT,\ SUS}$	Population	1.163	25.892
	$\gamma 2^{M,OUT,\ SUS}$	Unemployment	0.017[b]	
	$\theta 2^{M,OUT,\ SUS}$	Real wage[c]	−0.129[c]	
	$\eta 2^{M,OUT,\ SUS}$	Employment share	0[a]	
$\log(MIG2_{jt}^{OUT,\ HIGH})$	$\beta 2^{M,OUT,\ HIGH}$	Population	1.051	13.305
	$\gamma 2^{M,OUT,\ HIGH}$	Unemployment	0.017[b]	
	$\theta 2^{M,OUT,\ HIGH}$	Real wage[c]	−0.129[c]	
	$\eta 2^{M,OUT,HIGH}$	Employment share	0[a]	

The number of observations is 741. The standard errors of regression are 0.147, 0.150, 0.170 and 0.123 for *LOW*, *VOC*, *SUS* and *HIGH*, respectively

[a]A priori zerorestriction

[b]A priori restrictions$\gamma 2^{M,OUT,\ VOC} = \gamma 2^{M,OUT,\ SUS} = \gamma 2^{M,OUT,\ HIGH}$

[c]A priori restrictions $\theta 2^{M,OUT,\ VOC} = \theta 2^{M,OUT,\ SUS} = \theta 2^{M,OUT,\ HIGH}$

$$RHWAGEOTH2_t^e = \frac{\sum_{j\in R_2} POP_{jt}^e \times \mathrm{RHWAGE}_{jt}^e}{\sum_{j\in R_2} POP_{jt}^e}; e = \{LOW,\ VOC,\ SUS,\ HIGH\}, \tag{8}$$

$$UROTH1_t^e = \frac{\sum_{i\in R_1} POP_{it}^e \times UR_{it}^e}{\sum_{i\in R_1} POP_{it}^e},\ e = \{LOW, VOC, SUS, HIGH\}, \tag{9}$$

$$UROTH2_t^e = \frac{\sum_{j\in R_2} POP_{jt}^e \times UR_{jt}^e}{\sum_{j\in R_2} POP_{jt}^e},\ e = \{LOW, VOC, SUS, HIGH\}, \tag{10}$$

$$EMPSHAREOTH1_t^e = \frac{\sum_{i\in R_1} POP_{it}^e \times EMPSHAREOTH_{it}^e}{\sum_{i\in R_1} POP_{it}^e},\ e = \{LOW, VOC, SUS, HIGH\} \tag{11}$$

and

Table 26 Internal in-commuting to economic regions in group 1 from group 2. Iterative SUR-estimates

Left-hand variable	Parameter	Type of variable	Estimate	*t*-value
$\log(COM1_{it}^{IN,\ LOW})$	$\beta 1^{C,IN,\ LOW}$	Population	0.551	2.694
	$\gamma 1^{C,IN,\ LOW}$	Unemployment	−0.130	−2.823
	$\theta 1^{C,IN,\ LOW}$	Real wage	0.931	2.627
	$\eta 1^{C,IN,\ LOW}$	Employment share	0[a]	
$\log(COM1_{it}^{IN,\ VOC})$	$\beta 1^{C,IN,\ VOC}$	Population	1.213	7.275
	$\gamma 1^{C,IN,\ VOC}$	Unemployment	−0.193	−6.340
	$\theta 1^{C,IN,\ VOC}$	Real wage	0[a]	
	$\eta 1^{C,IN,\ VOC}$	Employment share	0[a]	
$\log(COM1_{it}^{IN,\ SUS})$	$\beta 1^{C,IN,\ SUS}$	Population	0.313	1.640
	$\gamma 1^{C,IN,\ SUS}$	Unemployment	0[a]	
	$\theta 1^{C,IN,\ SUS}$	Real wage	−1.385	−3.517
	$\eta 1^{C,IN,\ SUS}$	Employment share	1.354	1.793
$\log(COM1_{it}^{IN,\ HIGH})$	$\beta 1^{C,IN,\ HIGH}$	Population	0.516	3.650
	$\gamma 1^{C,IN,\ HIGH}$	Unemployment	−0.054	−1.637
	$\theta 1^{C,IN,\ HIGH}$	Real wage	−0.672	−2.741
	$\eta 1^{C,IN,HIGH}$	Employment share	0[a]	

The number of observations is 416. The standard errors of regression are 0.114, 0.111, 0.124 and 0.099 for *LOW*, *VOC*, *SUS* and *HIGH*, respectively

[a]A priori zero restriction

Table27 Internal out-commuting from economic regions in group 2 to group 1. IterativeSUR-estimates

Left-hand variable	Parameter	Type of variable	Estimate	*t*-value
$\log(COM2_{jt}^{OUT,\ LOW})$	$\beta 2^{C,OUT,\ LOW}$	Population	1.016	15.022
	$\gamma 2^{C,\ OUT,\ LOW}$	Unemployment	0.063	2.003
	$\theta 2^{C,\ OUT,\ LOW}$	Real wage	0[a]	
	$\eta 2^{C,\ OUT,\ LOW}$	Employment share	0.716	2.515
$\log(COM2_{jt}^{OUT,\ VOC})$	$\beta 2^{C,OUT,\ VOC}$	Population	0.952	11.592
	$\gamma 2^{C,\ OUT,\ VOC}$	Unemployment	−0.035	−1.788
	$\theta 2^{C,\ OUT,\ VOC}$	Real wage	0[a]	
	$\eta 2^{C,\ OUT,\ VOC}$	Employment share	−1.413	−2.441
$\log(COM2_{jt}^{OUT,\ SUS})$	$\beta 2^{C,OUT,\ SUS}$	Population	1.179	12.722
	$\gamma 2^{C,\ OUT,\ SUS}$	Unemployment	0[a]	
	$\theta 2^{C,\ OUT,\ SUS}$	Real wage	0[a]	
	$\eta 2^{C,\ OUT,\ SUS}$	Employment share	−0.667	−2.720
$\log(COM2_{jt}^{OUT,\ HIGH})$	$\beta 2^{C,OUT,\ HIGH}$	Population	1.303	12.744
	$\gamma 2^{C,\ OUT,\ HIGH}$	Unemployment	0[a]	
	$\theta 2^{C,\ OUT,\ HIGH}$	Real wage	0[a]	
	$\eta 2^{C,\ OUT,HIGH}$	Employment share	−1.521	−3.436

The number of observations is 741. The standard errors of regression are 0.142, 0.119, 0.115 and 0.124 for *LOW*, *VOC*, *SUS* and *HIGH*, respectively

[a]A priori zero restriction

$$EMPSHAREOTH2_t^e = \frac{\sum_{j\in R_2} POP_{jt}^e \times EMPSHAREOTH_{jt}^e}{\sum_{j\in R_2} POP_{jt}^e},\ e = \{LOW, VOC, SUS, HIGH\}. \tag{12}$$

In Eqs. (7) and (8) $RHWAGEOTH1_t^e$ and $RHWAGEOTH2_t^e$ denote, respectively, the population weighted mean real hourly wage rate in groups 1 and 2 among those with education e. In Eqs. (9) and (10) $UROTH1_t^e$ and $UROTH2_t^e$ denote, respectively, the population weighted unemployment rates in groups 1 and 2 among those with education e. Finally, in Eqs. (11) and (12) $EMPSHARE1_t^e$ and $EMPSHARE2_t^e$ denote, respectively, the population weighted mean real hourly wage rate in groups 1 and 2 among those with education e. In contrast to what was done in conjunction with the main model specification, we here apply sets of regressions containing four equations.

In the first set, we consider internal in-migration to economic regions in group 1 from group 2.

$$\begin{aligned}\log(MIG1_{it}^{IN,e}) =& \mu 1_i^{M,IN,e} + \lambda 1_t^{M,IN,e} + \beta 2^{M,IN,e}\log(POP_{\mathrm{it}}^e)\\ &+ \gamma 1^{M,IN,e} \times [\log(UR_{i,t-1}^e) - \log(UROTH2_{t-1}^e)]\\ &+ \theta 1^{M,IN,e} \times [\log(RHWAGE_{i,t-1}^e) - \log(RHWAGEOTH2_{t-1}^e)]\\ &+ \eta 1^{M,IN,e} \times [\log(EMPSHARE_{i,t-1}^e) - \log(EMPSHAREOTH2_{t-1}^e)] + \varepsilon 1_{it}^{M,IN,e},\\ e =& \{LOW, VOC, SUS, HIGH\},\ i \in R_1.\end{aligned} \tag{13}$$

In the second set, we consider internal out-migration from economic regions in group 2 to group 1.

$$\begin{aligned}\log(MIG2_{jt}^{OUT,e}) =& \mu 2_j^{M,OUT,e} + \lambda 2_t^{M,OUT,e} + \beta 2^{M,OUT,e}\log(POP_{jt}^e)\\ &+ \gamma 2^{M,OUT,e} \times [\log(UR_{j,t-1}^e) - \log(UROTH1_{t-1}^e)]\\ &+ \theta 2^{M,OUT,e} \times [\log(RHWAGE_{j,t-1}^e) - \log(RHWAGEOTH1_{t-1}^e)]\\ &+ \eta 2^{M,OUT,e} \times [\log(EMPSHARE_{j,t-1}^e) - \log(EMPSHAREOTH1_{t-1}^e)] + \varepsilon 2_{jt}^{M,OUT,e},\\ e =& \{LOW, VOC, SUS, HIGH\},\ j \in R_2.\end{aligned} \tag{14}$$

In the third set, we consider internal in-commuting to economic regions in group 1 from group 2.

$$\begin{aligned}\log(COM1_{it}^{IN,e}) =& \mu 1_i^{C,IN,e} + \lambda 1_t^{C,IN,e} + \beta 2^{C,IN,e}\log(POP_{it}^e)\\ &+ \gamma 1^{C,IN,e} \times [\log(UR_{i,t-1}^e) - \log(UROTH2_{t-1}^e)]\\ &+ \theta 1^{C,IN,e} \times [\log(RHWAGE_{i,t-1}^e) - \log(RHWAGEOTH2_{t-1}^e)]\\ &+ \eta 1^{C,IN,e} \times [\log(EMPSHARE_{i,t-1}^e) - \log(EMPSHAREOTH2_{t-1}^e)] + \varepsilon 1_{it}^{C,IN,e},\\ e =& \{LOW, VOC, SUS, HIGH\},\ i \in R_1.\end{aligned} \tag{15}$$

Finally, in the fourth set we consider internal out-commuting from economic regions in group 2 to group 1.

$$\begin{aligned}\log(COM2_{jt}^{OUT,e}) =& \mu 2_{j}^{C,OUT,e} + \lambda 2_{t}^{C,OUT,e} + \beta 2^{C,OUT,e}\log(POP_{jt}^{e}) \\ &+ \gamma 2^{C,OUT,e} \times [\log(UR_{j,t-1}^{e}) - \log(UROTH1^{e}_{t-1})] \\ &+ \theta 2^{C,OUT,e} \times [\log(RHWAGE_{j,t-1}^{e}) - \log(RHWAGEOTH1^{e}_{t-1})] \\ &+ \eta 2^{C,OUT,e} \times [\log(EMPSHARE_{j,t-1}^{e}) - \log(EMPSHAREOTH1_{t-1}^{e})] + \varepsilon 2_{jt}^{C,OUT,e}, \\ e =& \{LOW, VOC, SUS, HIGH\},\ j \in R_2.\end{aligned} \tag{16}$$

The symbols $\mu 2_{j}^{M,OUT,e}$, $\mu 1_{i}^{M,IN,e}$, $\mu 2_{j}^{C,OUT,e}$, $\mu 1_{i}^{C,OUT,e}$ $(j \in R_2; i \in R_1)$ denote fixed effects for the economic regions. The symbols $\lambda 2_{t}^{M,OUT,e}$, $\lambda 1_{t}^{M,IN,e}$, $\lambda 2_{t}^{C,OUT,e}$, $\lambda 1_{t}^{C,IN,e}$ denote fixed time effects. The (slope) parameters of interest are $\beta 2^{M,OUT,e}$, $\gamma 2^{M,OUT,e}$, $\theta 2^{M,OUT,e}$, $\eta 2^{M,OUT,e}$, $\beta 1^{M,IN,e}$, $\gamma 1^{M,IN,e}$, $\theta 1^{M,IN,e}$, $\eta 1^{M,IN,e}$, $\beta 2^{C,OUT,e}$, $\gamma 2^{C,OUT,e}$, $\theta 2^{C,OUT,e}$, $\eta 2^{C,OUT,e}$, $\beta 1^{C,IN,e}$, $\gamma 1^{C,IN,e}$, $\theta 1^{C,IN,e}$, $\eta 1^{C,IN,e}$; $e = \{LOW, VOC, SUS, HIGH\}$.

We make the following assumptions about the error terms $\varepsilon 2_{jt}^{M,OUT,e}$, $\varepsilon 1_{it}^{M,IN,e}$, $\varepsilon 2_{jt}^{C,OUT,e}$ and $\varepsilon 1_{it}^{C,IN,e}$, $e = \{LOW, VOC, SUS, HIGH\}$:

$$\varepsilon 1_{it}^{M,IN} = \left\{ \varepsilon 1_{it}^{M,IN,\ LOW},\ \varepsilon 1_{it}^{M,IN,\ VOC},\ \varepsilon 1_{it}^{M,\ IN,\ SUS},\ \varepsilon 1_{it}^{M,IN,\ HIGH} \right\}' \sim N(\underline{0}, \Omega 1^{M,IN}) \forall i \in R_1, \tag{17}$$

$$\varepsilon 2_{jt}^{M,OUT} = \left\{ \varepsilon 2_{jt}^{M,\ OUT,\ LOW},\ \varepsilon 2_{jt}^{M,\ OUT,\ VOC},\ \varepsilon 2_{jt}^{M,\ OUT,\ SUS},\ \varepsilon 2_{jt}^{M,\ OUT,\ HIGH} \right\}' \sim N(\underline{0}, \Omega 2^{M,\mathrm{OUT}}) \forall j \in R_2, \tag{18}$$

$$\varepsilon 1_{it}^{C,IN} = \left\{ \varepsilon 1_{it}^{C,IN,\ LOW},\ \varepsilon 1_{it}^{C,IN,\ VOC},\ \varepsilon 1_{it}^{C,\ IN,\ SUS},\ \varepsilon 1_{it}^{C,IN,\ HIGH} \right\}' \sim N(\underline{0}, \Omega 1^{C,IN}) \forall i \in R_1 \tag{19}$$

and

$$\varepsilon 2_{jt}^{C,OUT} = \left\{ \varepsilon 2_{jt}^{C,\ OUT,\ LOW},\ \varepsilon 2_{jt}^{C,\ OUT,\ VOC},\ \varepsilon 2_{jt}^{C,\ OUT,\ SUS},\ \varepsilon 2_{jt}^{C,\ OUT,\ HIGH} \right\}' \sim N(\underline{0}, \Omega 2^{C,OUT}) \forall j \in R_2, \tag{20}$$

In Eqs. (17)-(20) $\underline{0}$ denotes a zero vector of dimension 4×1 and $\Omega 1^{M,IN}$, $\Omega 2^{M,OUT}$, $\Omega 1^{C,IN}$ and $\Omega 2^{C,OUT}$ all denote 4×4 covariance matrices which are symmetric and positive definite, but otherwise unrestricted (see Tables 24, 25, 26, 27, 28 respectively, for the estimates of the parameters in the equations and additional symbols).

Table 28 Additional symbols encountered in Appendix E

Symbol	Description
$RHWAGEOTH1_t^{LOW}$	Population weighted real hourly wage rate for those with low education in main group 1 in year t
$RHWAGEOTH1_t^{VOC}$	Population weighted real hourly wage rate for those with vocational education in main group 1 in year t
$RHWAGEOTH1_t^{SUS}$	Population weighted real hourly wage rate for those with study-oriented upper secondary education in main group 1 in year t
$RHWAGEOTH1_t^{HIGH}$	Population weighted real hourly wage rate for those with high education in main group 1 in year t
$RHWAGEOTH2_t^{LOW}$	Population weighted real hourly wage rate for those with low education in main group 2 in year t
$RHWAGEOTH2_t^{VOC}$	Population weighted real hourly wage rate for those with vocational education in main group 2 in year t
$RHWAGEOTH2_t^{SUS}$	Population weighted real hourly wage rate for those with study-oriented upper secondary education in main group 2 in year t
$RHWAGEOTH2_t^{HIGH}$	Population weighted real hourly wage rate for those with high education in main group 2 in year t
$UROTH1_t^{LOW}$	Population weighted unemployment rate (in percent) for those with low education in main group 1 in year t
$UROTH1_t^{VOC}$	Population weighted unemployment rate (in percent) for those with vocational education in main group 1 in year t
$UROTH1_t^{SUS}$	Population weighted unemployment rate (in percent) for those with study-oriented upper secondary education in main group 1 in year t
$UROTH1_t^{HIGH}$	Population weighted unemployment rate (in percent) for those with high education in main group 1 in year t
$UROTH2_t^{LOW}$	Population weighted unemployment rate (in percent) for those with low education in main group 2 in year t
$UROTH2_t^{VOC}$	Population weighted unemployment rate (in percent) for those with vocational education in main group 2 in year t
$UROTH2_t^{SUS}$	Population weighted unemployment rate (in percent) for those with study-oriented upper secondary education in main group 2 in year t
$UROTH2_t^{HIGH}$	Population weighted unemployment rate (in percent) for those with high education in main group 2 in year t
$EMPSHAREOTH1_t^{LOW}$	Population weighted employment share for those with low education in main group 1 in year t
$EMPSHAREOTH1_t^{VOC}$	Population weighted employment share for those with vocational education in main group 1 in year t
$EMPSHAREOTH1_t^{SUS}$	Population weighted employment share for those with study-oriented upper secondary education in main group 1 in year t
$EMPSHAREOTH1_t^{HIGH}$	Population weighted employment share for those with high education in main group 1 in year t
$EMPSHAREOTH2_t^{LOW}$	Population weighted employment share for those with low education in main group 2 in year t
$EMPSHAREOTH2_t^{VOC}$	Population weighted employment share for those with vocational education in main group 2 in year t
$EMPSHAREOTH2_t^{SUS}$	Population weighted employment share for those with study-oriented upper secondary education in main group 2 in year t

Table 28 (continued)

Symbol	Description
$EMPSHAREOTH2_t^{HIGH}$	Population weighted employment share for those with high education in main group 2 in year t
$MIG1_{it}^{IN,LOW}$	Total internal in-migration to economic region i in main group 1 from main group 2 by those with low education, $i \in R_1$
$MIG1_{it}^{IN,VOC}$	Total internal in-migration to economic region i in main group 1 from main group 2 by those with vocational education, $i \in R_1$
$MIG1_{it}^{IN,SUS}$	Total internal in-migration to economic region i in main group 1 from main group 2 by those with study-oriented upper secondary education, $i \in R_1$
$MIG1_{it}^{IN,HIGH}$	Total internal in-migration to economic region i in main group 1 from main group 2 by those with high education, $i \in R_1$
$MIG2_{jt}^{OUT,LOW}$	Total internal out-migration from economic region j in main group 1 to main group 2 by those with low education, $j \in R_2$
$MIG2_{jt}^{OUT,VOC}$	Total internal out-migration from economic region j in main group 1 to main group 2 by those with vocational education, $j \in R_2$
$MIG2_{jt}^{OUT,SUS}$	Total internal out-migration from economic region j in main group 1 to main group 2 by those with study-oriented upper secondary education, $j \in R_2$
$MIG2_{jt}^{OUT,HIGH}$	Total internal out-migration from economic region j in main group 1 to main group 2 by those with high education, $j \in R_2$
$COM1_{it}^{IN,LOW}$	Total in-commuting to economic region i in main group 1 from main group 2 by those with low education, $i \in R_1$
$COM1_{it}^{IN,VOC}$	Total in-commuting to economic region i in main group 1 from main group 2 by those with vocational education, $i \in R_1$
$COM1_{it}^{IN,SUS}$	Total in-commuting to economic region i in main group 1 from main group 2 by those with study-oriented upper secondary education, $i \in R_1$
$COM1_{it}^{IN,HIGH}$	Total in-commuting to economic region i in main group 1 from main group 2 by those with high education, $i \in R_1$
$COM2_{jt}^{OUT,LOW}$	Total out-commuting from economic region j in main group 1 to main group 2 by those with low education, $j \in R_2$
$COM2_{jt}^{OUT,VOC}$	Total out-commuting from economic region j in main group 1 to main group 2 by those with vocational education, $j \in R_2$
$COM2_{jt}^{OUT,SUS}$	Total out-commuting from economic region j in main group 1 to main group 2 by those with study-oriented upper secondary education, $j \in R_2$
$COM2_{jt}^{OUT,HIGH}$	Total out-commuting from economic region j in main group 1 to main group 2 by those with high education, $j \in R_2$

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