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Abstract

The paper analyses drivers of migration in carbon-intensive and non-carbon-intensive regions in the EU. Using a mix of econometric methods, such as spatial panel and spatial cross-sectional methods, as well as geographically weighted regressions on data for EU NUTS-2 and NUTS-3 regions, the results indicate that particularly carbon-intensive regions in Central and Eastern Europe are not only challenged by a potential decline in carbon-intensive employment but also by outward migration flows that could diminish their prospects for longer-term economic prosperity. From a policy point of view, the results indicate that policies focusing on the replacement of the lost jobs in carbon-intensive industries might not be enough for the carbon-intensive regions in Central and Eastern Europe. Instead, these regions need a simultaneous package of additional policies to improve their attractiveness.

Keywords: carbon-intensive regions, green transition, regional migration

JEL classification: Q50, R11, R23

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1. Introduction

The year 2019 marked a fundamental strategic reorientation of EU policy. The European Commission, under the presidency of Ursula von der Leyen, defined six political priorities for the period 2019-2024 to prepare the EU for the future. These include a new push for European democracy, a bigger role for the EU on the global stage, an increase in economic prosperity for large parts of the population, the promotion of European core values, and digitisation of the European economy and society. The most important, however, is the European Green Deal (EGD). The main purpose of the EGD is to make Europe the first climate-neutral continent by 2050 and to transform the European economy to become more ecologically and environmentally sustainable.

This ambition was expressed not only in the European Climate Law (EU, 2021), enshrining a strong commitment to ecological transformation, but also by including far-reaching measures in the EGD (European Commission, 2019) in the following areas: investments in environmentally friendly technologies; support for innovation; environmentally friendly public and private transport; decarbonisation of the energy sector; and energy-efficient buildings. Investments in eco-transformation are co-ordinated and facilitated through the European Green Deal Investment Plan.

Achieving climate neutrality by 2050 and, as an intermediate step, a reduction of greenhouse gas (GHG) emissions to 55% of the 1990 level, is an ambitious task. Although GHG emissions in the EU have been decreasing in the past decade, there is substantial variation in the progress of the trajectory both at national and regional level. This implies that, for certain EU regions whose economies are highly energy- and carbon-intensive, there is a long way to go to reach climate neutrality and to reduce reliance on fossil fuels. Additionally, the need for green transition will differ greatly between economic sectors. Some sectors, such as production of steel, cement, basic chemicals (ethylene and ammonia) and paper, as well as oil refining, are highly energy- and carbon-intensive. Therefore, they require a higher degree of technological change and corresponding investments into R&D and physical capital to become climate-neutral than is the case for other sectors of economic activity.

As a consequence, the economic and social effects on the EU regions will differ greatly, depending on their general economic energy and carbon intensity, as well as their pattern of sectoral specialisation. According to the impact assessment (European Commission, 2020a) of the EU Communication ‘Stepping up Europe’s 2030 climate ambition’ (European Commission, 2020b), output in sectors such as fossil fuel production, as well as energy-intensive manufacturing sectors, is likely to shrink, because of high replacement cost to introduce new technologies without an increase in output (at least partly crowding out other investments) and a lower global competitiveness owing to higher energy prices, arising from increased use of renewable energy sources.

These developments will also have consequences for the labour market, as jobs in the most affected industries are likely to decline. Although new ‘green’ industries and jobs will be created simultaneously, there is no guarantee that this will occur in exactly the regions that face output and employment loss as a result of the green transition. Therefore, the economic effects of the green transition on the EU regions might be asymmetric, with some regions benefiting in terms of higher economic growth, while others suffer from a drop in output and associated negative social consequences.

The potential of EU regions to benefit from (or their likeliness to suffer from) the green transition depends on a number of factors and characteristics. These include a long list of more or less traditional growth factors, such as their innovation potential, skill base, sectoral structure, quality of governance, transport and digital infrastructure, accessibility, inter- and intra-industry linkages and spillovers, local demand etc.

The regions most affected by the green transition will be those whose economies currently specialise in carbon-intensive activities such as coal mining, oil refining and production of basic chemicals, steel and cement. Those regions are the focus of our analysis.

In this paper, we will also focus on a very specific aspect determining those regions' potentials to participate successfully in the green transition: migration. The role of regional migration in green transition is hardly accounted for in the literature, as data on migration and sectoral exposure to green transition are rare. This paper fills this gap by contributing both to the current policy debate on ecological change in Europe and also to the regional migration literature.

Studies suggest that migration inflows and outflows can have repercussions for the development and future prospects of regions. It is, therefore, important to analyse whether and why regions are attractive to individuals from other regions. More attractive regions are likely to have greater ability to tackle ongoing challenges, such as population ageing and brain drain. The lack of required inflows of potential workers and outflows of relevant workers can result in labour shortages and hinder the development of long-term growth potential. In addition, outflows of highly educated and young people can have important and adverse fiscal consequences for regions. The outflows of individuals with favourable characteristics correspond to a lack of public revenues that are needed for public goods and services.

Thus, outward migration plays an important role in regions' capacity to benefit from the green transition. For example, the decline of jobs in carbon-intensive industries in certain regions, if not substituted by new jobs, decreases local employment and local demand, thereby making the affected regions less attractive places to live and work. Consequently, carbon-intensive regions may be more prone to experience outward migration that adversely affects socioeconomic developments. More specifically, outward migration can substantially change the structure of the population, leading to cumulative negative processes in terms of social demography (Wirth et al., 2012). As migration is usually selective, those who leave are the most vital population groups (OECD, 2012). Outward migration may thereby influence fertility rates and human capital accumulation in affected regions (Shayegh, 2017).

In addition to the change in the population structure, the outward migration of medium- to high-income groups may weaken the demand for goods and services of the locally oriented economy, reducing its competitiveness. Consequently, the remaining population lacks equal opportunities in times of transition, in many cases because of the declining quantity and quality of economic and social infrastructure (Rodríguez-Pose, 2018). Additionally, outward migration, particularly of young, educated population segments, diminishes a region's skill base and limits its potential to effectively restructure the regional economy. This may create a vicious circle of economic and social decline, as such regions will fall behind more successful regions, triggering even more outward migration and limiting their long-run growth potential.

A large strand of the literature already addresses the push and pull factors for migration dynamics across regions. Theoretically, the individual's decision to migrate is seen as determined by the expected benefits and expected costs of moving. Favourable regional (economic) conditions are likely to correspond to higher expected benefits and thus can induce individuals to move to regions. In contrast, as poor local conditions mean that expected benefits are relatively low, this can increase the propensity to move out.

Below, we review empirical analyses that assess the determinants of regional migration.

Rodríguez-Pose and Ketterer (2012) analyse push and pull factors for net migration dynamics of 133 European regions for the period 1990-2006. Specifically, they evaluate the role of specific economic and socio-demographic factors, but also look at the impact of local amenities. Their findings emphasise the importance of economic factors, but also suggest that socio-demographic characteristics are relevant to attract migration.

Buch et al. (2014) explore the determinants of net migration rates of German cities covering the period from 2000 to 2007. They focus predominantly on labour migration and evaluate to what extent local labour market conditions and amenities shape urban migration dynamics in Germany. Their findings suggest that availability of job opportunities, as reflected by a lower unemployment rate, and also the prospect of future employment and higher income, as indicated by regional employment growth, attract an inflow of individuals. However, the results also show that the quality of life that cities offer plays a role in migration decisions.

Sardadvar and Vakulenko (2017) further examine the relevance of determinants of migration of 78 regions in Russia. In addition to the net migration, they also look exclusively at in-migration and out-migration, and split total migration into internal and external flows. Importantly, the authors do not only analyse the role of the regions' own economic and socioeconomic characteristics for migration, but also provide insights into the relevance of characteristics of neighbouring regions by employing spatial econometric approaches. Their results illustrate that economic dynamics in nearby regions also influence local migration dynamics.

The importance of factors in neighbouring regions for regions' migration behaviour is also reported in the results of Etzo (2011). Using bilateral migration flows between Italian regions for the period 1996-2005, he shows that a higher income level and a lower unemployment rate in other regions are important pull effects for internal migration flows.

2. Data

The carbon-intensive regions in the EU in our analysis are defined at the regional NUTS-2 level, according to their employment share in either the mining sector or in carbon-intensive manufacturing industries. These industries are chemicals (ethylene, ammonia), non-metallic minerals (cement), manufacture of basic metals (steel), coke and refined petroleum products.

The basis of the classification is the Eurostat structural business statistics (SBS), which supply regional employment data at the sectoral NACE Rev. 2 2-digit level. Unfortunately, the initial SBS data are not harmonised over time and are subject to limitations regarding availability and coverage. For the purpose of the analysis, the initial SBS data have been harmonised to be in line with NUTS-2 2016 and NACE Rev. 2 codes. Moreover, the harmonised SBS data are combined with industry-level employment data from national accounts and regional accounts in order to fill gaps and balance the information about employment available in the different data sources.[1]

Industry-specific employment data by NUTS-3 region come from the Annual Regional Database of the European Commission's Directorate General for Regional and Urban Policy (ARDECO). Importantly, however, the data are available only at a rather aggregated industry level (A, B-E, F, G-J, K-N and O-U).

Regional information about socio-demographic characteristics (for instance, on educational attainment, age cohorts) and further labour market indicators (e.g. unemployment rate) are taken from the publicly available EU labour force survey (EU-LFS) from Eurostat. Information about real GDP per capita is also available in the ARDECO, at both NUTS-2 and NUTS-3 levels.

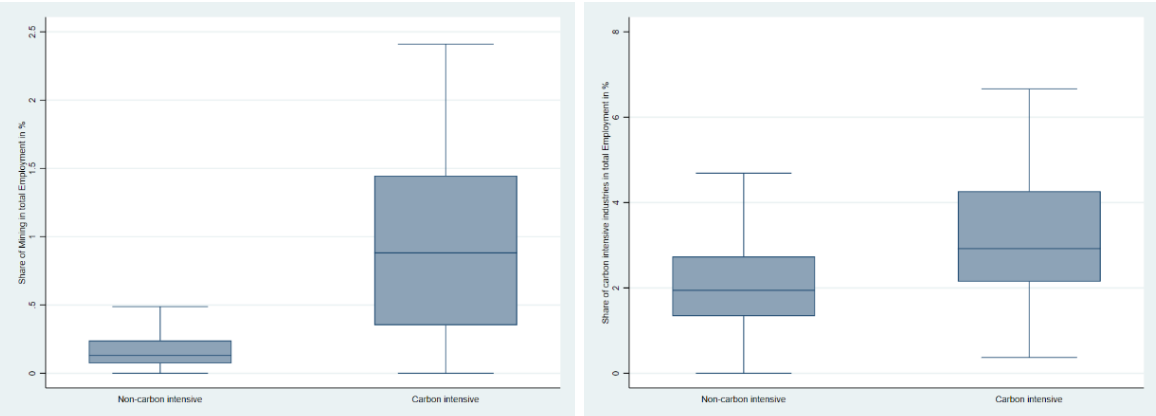
The carbon-intensive regions are defined as the top 10% EU NUTS-2 regions in terms of their employment share either in the mining industry or in the carbon-intensive manufacturing industries. This resulted in 34 carbon-intensive NUTS-2 regions. They are listed in Table 1.

[1] More specifically, in order to use information from both data sources, we apply the RAS method, which is an iterative scaling method. In doing so, the employment data in the SBS are rescaled in an iterative sequence such that the sums in countries and regions across the defined industries converge to the corresponding sums in the national and regional accounts.

Table 1 / Carbon-intensive regions

NUTS-code	Region	NUTS-code	Region
BE21	Prov. Antwerpen	HU22	Nyugat-Dunántúl
BE31	Prov. Brabant wallon	HU31	Észak-Magyarország
BG32	Severen tsentralen	ITC1	Piemonte
BG34	Yugoiztochen	ITG2	Sardegna
BG41	Yugozapaden	ITH2	Provincia Autonoma di Trento
CZ04	Severozápad	PL21	Malopolskie
CZ05	Severovýchod	PL22	Slaskie
CZ08	Moravskoslezsko	PL51	Dolnoslaskie
DE11	Stuttgart	PL52	Opolskie
DEA2	Köln	PL72	Swietokrzyskie
DEA3	Münster	PT16	Centro
DEB3	Rheinhessen-Pfalz	PT18	Alentejo
DEC0	Saarland	RO31	Sud - Muntenia
EE00	Eesti	RO41	Sud-Vest Oltenia
EL53	Dytiki Makedonia	RO42	Vest
ES12	Principado de Asturias	SE33	Övre Norrland
ES41	Castilla y León	SK04	Východné Slovensko

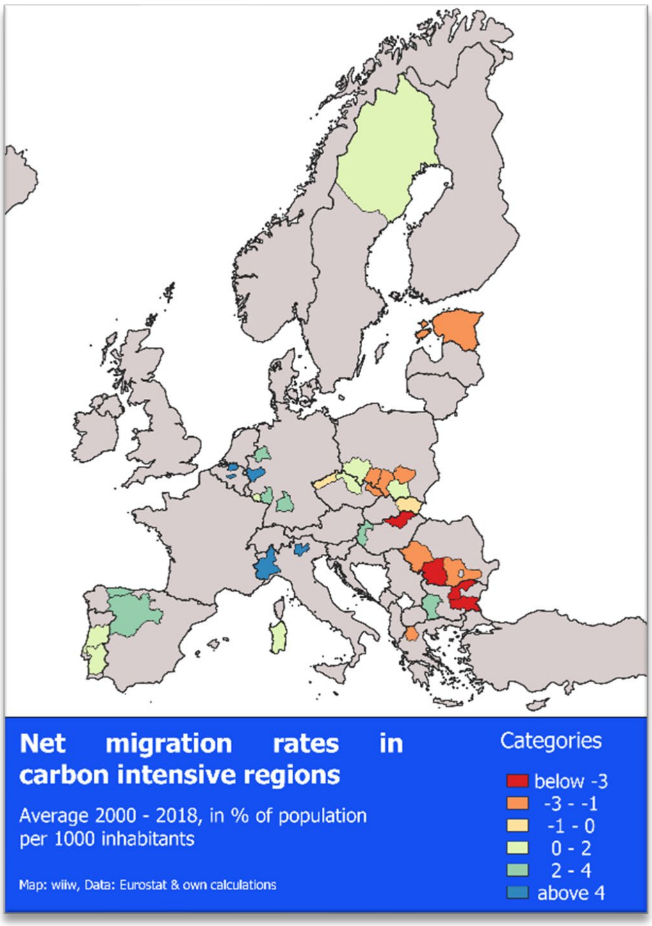
Figure 1 / Comparison of effects in carbon-intensive and non-carbon-intensive regions for selected variables



Sources: Eurostat; own calculations.

The geographic distribution of the net migration rates in carbon-intensive regions is illustrated in Figure 2. It shows that there is a split in the carbon-intensive regions in the EU regarding their net migration balance. Thus, carbon-intensive regions in Western EU countries, including Sweden, tend to have positive net migration rates, i.e. a net inflow of people, while such regions in Central and Eastern Europe are characterised by negative net migration rates. This will be kept in mind when developing policy conclusions, as the negative effects associated with negative migration balances only apply to the Eastern European carbon-intensive regions.

Figure 2 / Net migration rates in carbon-intensive regions



Sources: Eurostat; own calculations.

3. Econometric approach

The aim is to study the main drivers of mobility patterns of EU regions and to examine heterogeneous impacts across carbon-intensive and non-carbon-intensive regions. Specifically, this analysis explores to what extent economic and socio-demographic conditions impact differently the regional net migration rates of the two groups. To do so, we build on the empirical framework of Rodríguez-Pose and Ketterer (2012), Buch et al. (2014) and Sardadvar and Vakulenko (2017), and estimate the following specification by using panel data for the period 2000-2018 separately for carbon-intensive and non-carbon-intensive regions:

$$NMIG_{rt} = \varphi NMIG_{rt-1} + \boldsymbol{X}'_{rt-1}\beta + \boldsymbol{WX}'_{rt-1}\theta + \mu_r + \varepsilon_{rt}, \quad (1)$$

where $NMIG_{rt}$ denotes the net migration rate of a region r at time t. The $NMIG_{rt-1}$is the time-lagged region's net migration rate that accounts for the impact of past migration trends on current dynamics. The literature also sees this variable as a proxy for the availability of social network linkages (e.g. Rodríguez-Pose and Ketterer, 2012). Social networks can considerably improve the information flow about new job options and possibilities abroad, which tends to reduce uncertainty and thus increase the propensity to migrate. $\boldsymbol{X_{rt-1}}$ is a $k \times 1$ vector that includes place-specific characteristics, while $\boldsymbol{WX_{rt-1}}$ is an $h \times 1$ vector containing economic characteristics of neighbouring regions. μ_r controls for region-specific time-invariant characteristics and the remaining ε_{rt} is the error term.

In the analysis, we distinguish between regional (socio-)demographic and economic characteristics. As concerns *(socio)-demographic* regional features, we include the following factors:

Log(active pop), Population density: intend to proxy the region's size and capture potential agglomeration and congestion effects.

Share of individuals aged between 35-54 (in % of total population) and highly educated (in % of working-age population): control for the socio-demographic structure of a region. A favourable socio-demographic structure may signal a region's attractiveness and indicates long-term (economic) potentials shaped by localised knowledge spillovers. In general, migration patters are likely to vary across age cohorts (older individuals are less mobile) and educational attainment groups (the highly educated tend to exhibit a higher propensity to move).

In addition, we add the following regional *economic* characteristics to our specification:

Unemployment rate: controls for place-specific labour market conditions. Specifically, it indicates regional job availability and opportunities and represents a standard push factor for mobility patterns (Etzo, 2011).

Log(GDP in PPP per capita): controls for the level of economic development of a region and signals the regional wealth and welfare level. It represents one of the fundamental pull factors for mobility. In contrast, a high level of economic development can go hand in hand with high costs of living, which may hinder large inflows.

Share of employed individuals in agriculture (A), mining and quarrying (B), manufacturing (C), and services (G-J) in % of total employment: controls for the general place-specific economic structure and captures to some extent economic specialisation that can impact migration patterns.

(Sectoral) employment growth: employment growth and related changes in labour demand capture (sectoral) employment dynamics within a region. Such changes in (sectoral) labour demand are likely to correlate to prospects of future employment and income expectations that influence migration decisions (Sardadvar and Vakulenko, 2017). We consider the total regional employment growth, but also sectoral regional employment growth.

Regional migration dynamics are likely to be not only affected by the regions' own economic situation but might also depend on economic factors in neighbouring regions (Etzo, 2011). For instance, employment prospects in regions can exert influence on migration dynamics in neighbouring regions. To account for economic dynamics of neighbouring regions in specification (1), we consider spatially lagged regional factors as denoted by $\boldsymbol{WX_{rt-1}}$. $\boldsymbol{W}$ represents a spatial weight matrix that defines the neighbouring regions of each region r. Thus, we run a so-called SLX model and account for local economic spillover effects by introducing $\boldsymbol{WX_{rt-1}}$ (Vega and Elhorst, 2013). The spatial econometric literature also proposes to consider global spillovers (LeSage and Pace, 2009). However, the literature communicates important advantages of the SLX model and recommends its application (Vega and Elhorst, 2013; Corrado and Fingleton, 2012). Importantly, even though specification (1) is estimated separately for carbon-intensive and non-carbon-intensive regions, $\boldsymbol{WX_{rt-1}}$ accounts for all neighbours whether they are carbon-intensive or non-carbon-intensive regions. To implement the spatial lag, we apply a distance-based spatial weight $\boldsymbol{W}$ matrix. Its elements w_{rj} are based on the distance between the region r and j and are defined in the following way:

$$\begin{cases} w_{rj} = 1 \; if \; d_{rj} \leq d_j^*(k) \forall r, j = 1, \ldots, R; \; r \neq j \\ w_{rj} = 0 if \; d_{rj} > d_j^*(k), \end{cases}$$

where $d_j^*(k)$ indicates the nearest neighbours k of a region r. We choose to consider the eight nearest neighbours of a region by taking the number that results in the lowest sum of the squared residuals. $\boldsymbol{W}$ is row-standardised.

To estimate specification (1), we apply two different econometric estimators. First, we estimate a non-dynamic specification (without $NMIG_{rt-1}$) in an ordinary least squares framework. Second, we use a bias-corrected least squares dummy variable estimator (LSDV) as introduced by Kiviet (1995) to estimate a dynamic specification. For both estimators, we report heteroscedasticity-robust standard errors.

4. Results

In order to explore the heterogeneous impacts of economic and socio-demographic conditions on mobility patterns, we estimate specification (1) using NUTS-2 panel data for the period 2001-2018. In a first step, we estimate our baseline specification without considering effects of neighbouring regions. Table 2 presents the results for the baseline specification by considering total regional employment growth. Columns (1) and (2) list the estimation results for fixed-effects least squares estimation, while columns (3) and (4) show the results for the bias-corrected LSDV estimation.

Table 2 / Baseline specification

Dependent variable:	**Net migration rate**			
Subgroup:	**non-carbon**	**carbon**	**non-carbon**	**carbon**
	(1)	**(2)**	**(3)**	**(4)**
Lagged net migration rate	-	-	0.527***	0.0996**
	(-)	(-)	(0.0162)	(0.0480)
Active population, log	-14.56***	-10.91*	-11.62***	-10.93***
	(2.879)	(5.401)	(1.776)	(3.207)
Population density	-0.00741***	-0.0150	-0.00508***	-0.00164
	(0.00246)	(0.0245)	(0.00151)	(0.0250)
Share of population aged 35-54	-0.290***	-0.522**	-0.115***	-0.473**
	(0.0860)	(0.195)	(0.0357)	(0.197)
Share of highly educated population	0.105*	-0.324***	0.104***	-0.310***
	(0.0623)	(0.0732)	(0.0324)	(0.0907)
Unemployment rate	-0.285***	-0.201***	-0.0850**	-0.180**
	(0.0598)	(0.0669)	(0.0332)	(0.0810)
Employment share in agriculture	0.228*	0.167	0.164**	0.166
	(0.119)	(0.240)	(0.0720)	(0.140)
Employment share in mining and quarrying	0.638	-0.0829	0.162	-0.0957
	(1.048)	(0.667)	(1.059)	(0.353)
Employment share in manufacturing	0.401***	0.0198	0.265**	0.0288
	(0.138)	(0.135)	(0.104)	(0.193)
Employment share in services	-0.478***	-0.0589	-0.285***	-0.0145
	(0.151)	(0.245)	(0.0647)	(0.293)
GDP in PPP per capita, log	6.268***	6.919**	3.877***	6.470***
	(1.647)	(2.608)	(0.668)	(1.922)
Employment growth	0.182***	0.00561	0.154***	-0.00137
	(0.0630)	(0.0551)	(0.0248)	(0.0185)
Observations	3,283	582	3,255	580
Number of regions	196	33	196	33
Region-FE	Y	Y	Y	Y

Notes: Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1
‘carbon’ relates to carbon-intensive EU NUTS-2 regions, as defined in chapter 2. Columns (1) and (2) report the results for the least squares estimation, while columns (3) and (4) show the results for the bias-corrected least squares dummy variable estimation. Robust standard errors in parentheses.

Overall, the results for non-carbon-intensive and carbon-intensive regions are revealed to be similar for the non-dynamic and dynamic estimators. As can be seen, some considered covariates point to homogenous effects in both non-carbon-intensive and carbon-intensive regions. Active population and population density are shown to be predominantly negatively associated with the regional net migration rate. However, the results for population density are not statistically different from zero in non-carbon-intensive regions. These negative effects may reflect congestion costs resulting from a larger active population and a higher population density in a region. The share of the population between 35-54 years points to a negative effect in both carbon-intensive and non-carbon-intensive regions. The regional unemployment rate indicates the expected push effects in both groups of regions. Similarly, the place-specific economic structure tends to show similar effects in both groups. Importantly, however, the economic structure seems to be of less importance for migration dynamics in carbon-intensive regions than in non-carbon-intensive ones. Finally, we find similar results for our variable that captures the level of regional economic development. The results suggest that the regional welfare level acts as a significant pull factor.

Given these rather homogenous effects for non-carbon-intensive and carbon-intensive regions, we also find regional conditions that differ between the two groups of regions (i.e. the difference between the estimated coefficient is statistically significant).

For the time-lagged net migration rate, we find that the past migration dynamics exert a positive effect on current migration dynamics in both groups of regions. However, the effect is more important for non-carbon-intensive regions than for carbon-intensive regions. Thus, social network effects seem to be more relevant for non-carbon-intensive regions, which may also imply that local and social ties are more pronounced in carbon-intensive regions. Interestingly, the results for the share of highly educated individuals show diverging effects. We find a positive effect on the net migration rate for non-carbon-intensive regions, but a negative effect for carbon-intensive regions. When we interpret this variable as an indicator for a region’s attractiveness and an indicator for long-term potentials, the results suggest that carbon-intensive regions are less attractive than non-carbon-intensive regions. And finally, we observe a positive effect of employment growth on net migration in non-carbon-intensive regions. Thus, prospects of employment and income seem to increase the propensity to move to these regions. Interestingly, however, employment growth does not seem to pull migration to carbon-intensive regions.

In order to provide more insights into heterogeneous effects of employment growth on migration dynamics, we consider regional employment growth separately in agriculture, mining and quarrying, manufacturing, and services as explanatory variables. Table 3 provides the estimation results for this additional specification. Overall, the results of the covariates other than sectoral employment growth remain robust. Interestingly, the results for the sectoral employment growth variables point to significant differences between non-carbon-intensive and carbon-intensive regions. Employment dynamics in manufacturing and services are important for pulling individuals to non-carbon-intensive regions. In contrast, employment dynamics in manufacturing and in services do not seem to be related to migration dynamics in carbon-intensive regions. These results are consistent with the findings for total employment growth. However, we can also find similarities between non-carbon-intensive and carbon-intensive regions. A growing agriculture sector is shown to have a negative effect on the net migration rate in both types of regions, which indicates that individuals seem to perceive an association with lower employment and income prospects.

In the baseline specifications, we use the yearly net migration rates in the considered EU NUTS-2 regions as the dependent variable. In order to smooth short-run dynamics and account for outliers, we also generate mean values by using a three-year moving window and apply this variable as an alternative dependent variable. The results of this specification were revealed to be consistent with the results of the baseline specifications.

Table 3 / Baseline specification, sectoral employment growth

Dependent variable:	**Net migration rate**			
Subgroup:	**non-carbon**	**carbon**	**non-carbon**	**carbon**
	(1)	**(2)**	**(3)**	**(4)**
Lagged net migration rate	-	-	0.513***	0.1000*
	(-)	(-)	(0.0133)	(0.0593)
Active population, log	-15.07***	-10.72**	-11.60***	-10.72**
	(3.127)	(5.174)	(1.270)	(4.219)
Population density	-0.00522***	-0.0197	-0.00260	-0.00734
	(0.00114)	(0.0249)	(0.00162)	(0.0449)
Share of population aged 35-54	-0.359***	-0.514**	-0.172***	-0.465***
	(0.0799)	(0.194)	(0.0440)	(0.129)
Share of highly educated population	0.1000	-0.319***	0.0832**	-0.304***
	(0.0607)	(0.0724)	(0.0346)	(0.0811)
Unemployment rate	-0.250***	-0.193***	-0.0640***	-0.171**
	(0.0608)	(0.0645)	(0.0246)	(0.0711)
Employment share in agriculture	0.117	0.0808	0.0563	0.0814
	(0.123)	(0.237)	(0.0564)	(0.173)
Employment share in mining and quarrying	0.515	-0.124	-0.0140	-0.119
	(1.143)	(0.618)	(1.024)	(0.586)
Employment share in manufacturing	0.457***	-0.0153	0.313***	-0.00743
	(0.142)	(0.132)	(0.0905)	(0.144)
Employment share in services	-0.550***	-0.147	-0.342***	-0.106
	(0.156)	(0.277)	(0.0826)	(0.275)
GDP in PPP per capita, log	5.973***	6.508**	3.848***	6.106***
	(1.715)	(2.612)	(0.902)	(2.075)
Employment growth in agriculture	-0.0194*	-0.0460**	-0.0275**	-0.0493*
	(0.0109)	(0.0208)	(0.0131)	(0.0273)
Employment growth in mining and quarrying	0.00239	0.00210	0.000248	0.00305
	(0.00363)	(0.00770)	(0.00282)	(0.00582)
Employment growth in manufacturing	0.0643***	0.000939	0.101***	0.00354
	(0.0201)	(0.0224)	(0.0195)	(0.0303)
Employment growth in services	0.0799*	-0.0126	0.0553**	-0.0146
	(0.0477)	(0.0455)	(0.0281)	(0.0527)
Observations	3,155	563	3,127	561
Number of regions	189	32	189	32
Region-FE	Y	Y	Y	Y

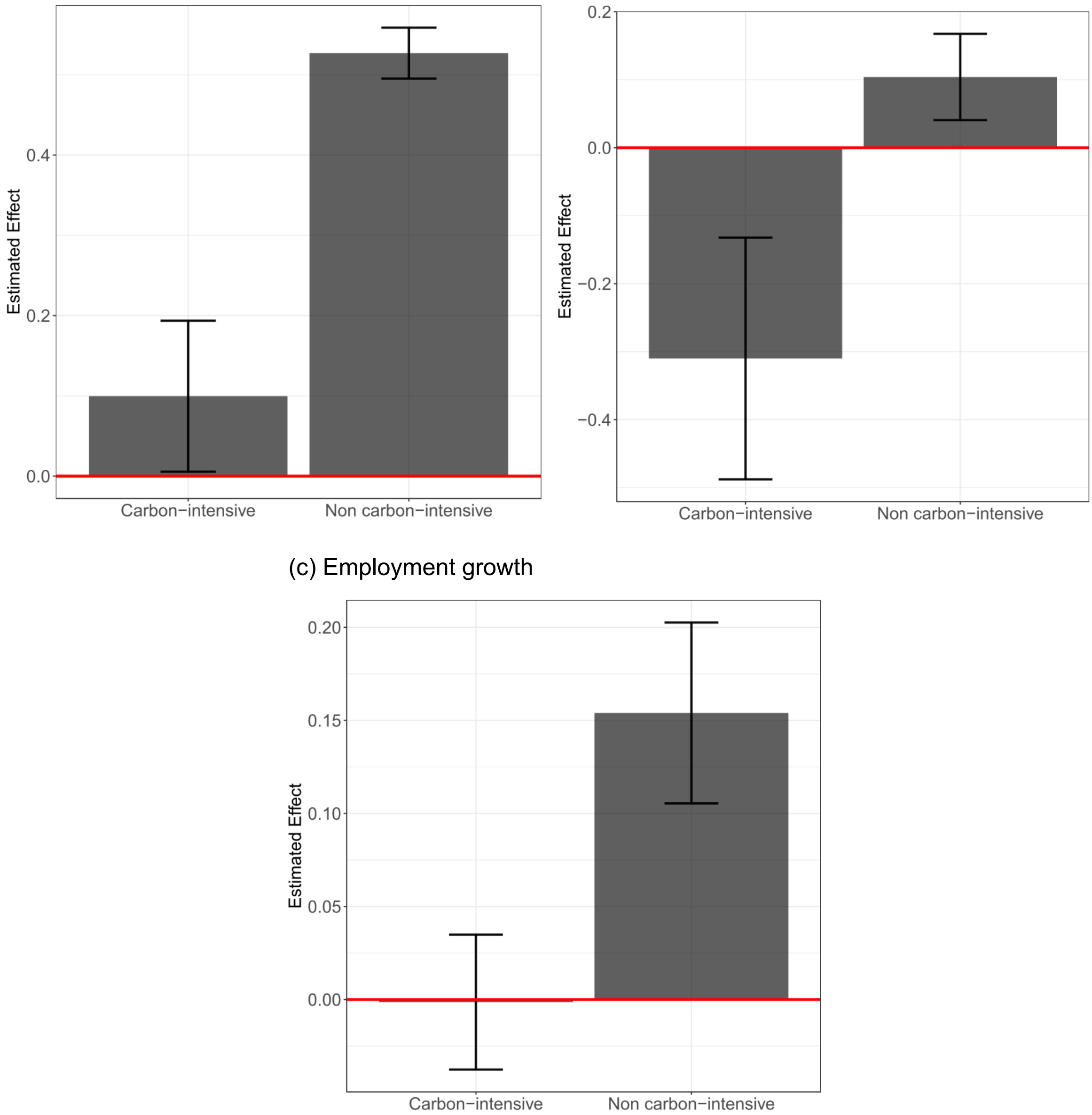
Notes: Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1
'carbon' relates to carbon-intensive EU NUTS-2 regions, as defined in chapter 2. Columns (1) and (2) report the results for the least squares estimation, while columns (3) and (4) show the results for the bias-corrected least squares dummy variable estimation. Robust standard errors in parentheses.

Figure 3 / Comparison between effects in carbon-intensive and non-carbon-intensive regions for selected variables

(a) Lagged migration rate

(b) Share of highly educated population

(c) Employment growth



Notes: The graphs plot the estimated results of (a) the lagged migration rate, (b) the share of the highly educated population, and (c) the total employment growth for carbon-intensive and non-carbon-intensive regions, obtained from the estimation of the baseline specification (see Table 2). The bars illustrate the estimated coefficients, and the whiskers indicate the 95% confidence interval.

4.1. ACCOUNTING FOR LOCAL ECONOMIC SPILLOVER EFFECTS

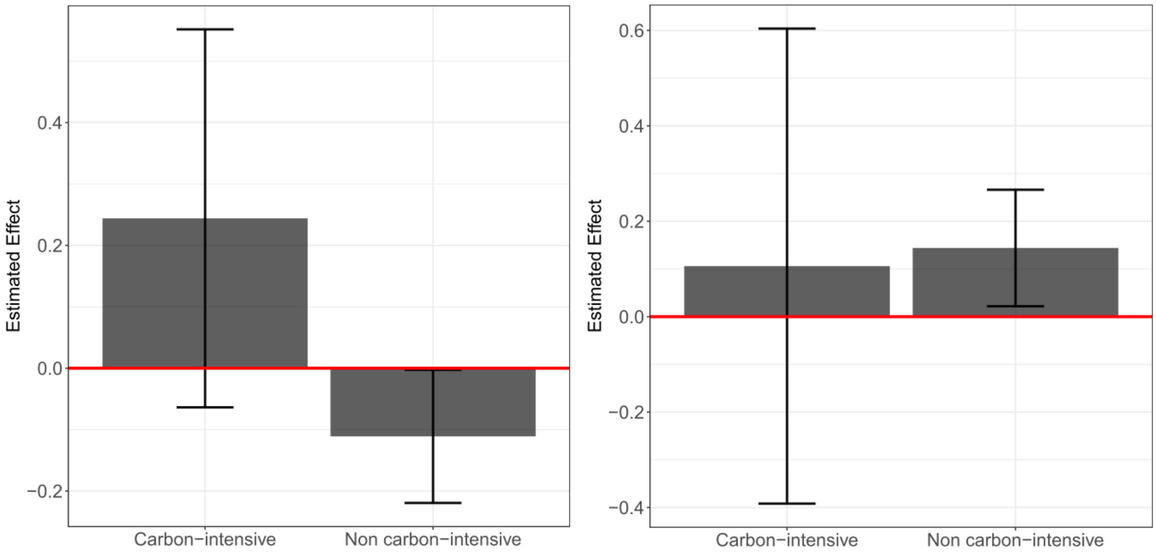
In the next step, we augment the baseline specifications and consider economic factors of neighbouring regions as additional covariates to account for local economic spillover effects. In doing so, we consider the eight nearest neighbours of each NUTS-2 region, irrespective of whether the region is carbon-intensive or non-carbon-intensive.

Table 4 presents the estimation results for the SLX model by incorporating total employment growth. The table is structured into two panels: The first panel shows the results for the region's own characteristics, while the second provides the results for the economic effects emanating from neighbouring regions.

The results for the region's own characteristics are in line with the results of the baseline specification presented above. We find similar diverging effects between non-carbon-intensive regions and carbon-intensive regions as found in the baseline results. Next, we turn to the results for the economic characteristics of neighbouring regions, i.e. our spatially lagged variables. Interestingly, we find different results for the spatially lagged unemployment rate and the spatially lagged total employment growth. The results of these two variables are contrasted in Figure 4. A higher unemployment rate in neighbouring regions induces individuals to move out of non-carbon-intensive regions, but we do not find a statistically significant effect for carbon-intensive regions. Importantly, in non-carbon-intensive regions, the region-specific local unemployment rate is seen to have a weaker effect than the unemployment rate in neighbouring regions. In contrast, the region-specific local unemployment rate has a predominant effect on the net migration rate in carbon-intensive regions. The estimated effect of the spatially lagged unemployment rate is positive, but not statistically significant. We find a statistically significant effect for total employment growth for non-carbon-intensive regions, but not for carbon-intensive regions. Employment dynamics in neighbouring regions therefore seem to induce individuals to move to non-carbon-intensive regions. Similar to the unemployment rate, the effect of total employment growth in neighbouring regions is more relevant for the net migration rate than the region-specific total employment growth. These findings indicate that local labour markets are considerably connected across regions for non-carbon-intensive regions. But labour market cross-regional dependencies are of less importance for the net migration rate of carbon-intensive regions.

Figure 4 / Comparison between effects in carbon-intensive and non-carbon-intensive regions for selected spatially lagged variables

(a) Spatially lagged unemployment rate (b) Spatially lagged total employment growth



Notes: The graphs plot the estimated results of the spatially lagged (a) unemployment rate, (b) total employment growth for carbon-intensive and non-carbon-intensive regions, obtained from the estimation of the baseline specification (see Table 3). The bars illustrate the estimated coefficients, and the whiskers indicate the 95% confidence interval.

Analogous to the specifications above, we also estimate the SLX model by including sectoral employment growth (see Table 5). Again, the results suggest pronounced interdependencies of labour markets across regions for non-carbon-intensive regions. In contrast, labour markets in carbon-intensive regions seem to function more independently from neighbouring regions. We find a negative impact of the region-specific unemployment rate, but a positive impact of the spatially lagged unemployment rate in carbon-intensive regions. Accordingly, a higher unemployment rate in neighbouring regions induces individuals to move to carbon-intensive regions. Moreover, employment dynamics in manufacturing in neighbouring regions tend to be influential for the net migration rate in both groups of regions. Both estimated effects are positive, but only weakly statistically significant. No further industry employment dynamics of neighbouring regions play a role for migration dynamics in carbon-intensive regions.

Table 4 / Specification with spatially lagged variables

Dependent variable:	**Net migration rate**			
Subgroup:	**non-carbon**	**carbon**	**non-carbon**	**carbon**
	(1)	**(2)**	**(3)**	**(4)**
Region's characteristics:				
Lagged net migration rate	-	-	0.521***	0.0526
	(-)	(-)	(0.0152)	(0.0433)
Active population, log	-14.00***	-11.90**	-11.38***	-12.06***
	(2.979)	(5.196)	(1.661)	(3.070)
Population density	-0.00724***	-0.0518**	-0.00518***	-0.0394
	(0.00255)	(0.0216)	(0.00154)	(0.0252)
Share of population aged 35-54	-0.313***	-0.489**	-0.116**	-0.459***
	(0.107)	(0.195)	(0.0480)	(0.176)
Share of highly educated population	0.0924*	-0.349***	0.0908**	-0.349***
	(0.0511)	(0.0964)	(0.0450)	(0.0979)
Unemployment rate	-0.152*	-0.242**	-0.0366	-0.236**
	(0.0799)	(0.101)	(0.0407)	(0.106)
Employment share in agriculture	0.133	0.221	0.102	0.215
	(0.157)	(0.217)	(0.0704)	(0.151)
Employment share in mining and quarrying	0.649	0.0821	0.227	0.113
	(1.106)	(0.682)	(1.013)	(0.401)
Employment share in manufacturing	0.382**	0.0180	0.264***	0.0220
	(0.178)	(0.119)	(0.101)	(0.249)
Employment share in services	-0.519***	0.0789	-0.307***	0.105
	(0.155)	(0.282)	(0.0772)	(0.317)
GDP in PPP per capita, log	6.178**	1.845	2.673***	1.495
	(2.671)	(3.215)	(0.975)	(4.372)
Employment growth	0.119	-0.0289	0.0857***	-0.0434
	(0.0768)	(0.0640)	(0.0314)	(0.0824)
Spatially lagged characteristics:				
Unemployment rate	-0.258**	0.226	-0.111**	0.244
	(0.109)	(0.222)	(0.0553)	(0.157)
Employment share in agriculture	0.594**	-0.809	0.336**	-0.837***
	(0.288)	(0.564)	(0.162)	(0.271)
Employment share in mining and quarrying	-2.735	3.639	-2.269	3.892*
	(2.546)	(2.633)	(1.465)	(2.242)
Employment share in manufacturing	-0.0411	0.0350	-0.0316	0.0654
	(0.214)	(0.373)	(0.121)	(0.294)
Employment share in services	0.463*	-1.283**	0.222*	-1.303***
	(0.243)	(0.514)	(0.126)	(0.431)
GDP in PPP per capita, log	0.215	7.782	1.345	8.085
	(2.107)	(6.124)	(1.384)	(4.982)
Employment growth	0.149	0.0884	0.144**	0.106
	(0.138)	(0.111)	(0.0623)	(0.254)
Observations	3,283	582	3,255	580
Number of regions	196	33	196	33
Region-FE	Y	Y	Y	Y

Notes: Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1
'carbon' relates to carbon-intensive EU NUTS-2 regions, as defined in chapter 2. Columns (1) and (2) report the results for the least squares estimation, while columns (3) and (4) show the results for the bias-corrected least squares dummy variable estimation. The spatially lagged characteristics are calculated by considering the eight nearest neighbours. Robust standard errors in parentheses.

Table 5 / Specification with spatially lagged variables, sectoral employment growth

Dependent variable:	**Net migration rate**			
Subgroup:	**non-carbon (1)**	**carbon (2)**	**non-carbon (3)**	**carbon (4)**
Region's characteristics:				
Lagged net migration rate	-	-	0.500***	0.0749
	(-)	(-)	(0.0142)	(0.0574)
Active population, log	-13.77***	-10.62**	-10.89***	-10.61**
	(3.306)	(5.126)	(1.323)	(4.468)
Population density	-0.00499***	-0.0591**	-0.00263*	-0.0496
	(0.00109)	(0.0219)	(0.00148)	(0.0436)
Share of population aged 35-54	-0.393***	-0.523**	-0.191***	-0.498***
	(0.0954)	(0.197)	(0.0345)	(0.107)
Share of highly educated population	0.0805	-0.377***	0.0621*	-0.372***
	(0.0512)	(0.102)	(0.0317)	(0.0826)
Unemployment rate	-0.104	-0.223**	-0.0259	-0.208**
	(0.0796)	(0.0942)	(0.0413)	(0.104)
Employment share in agriculture	0.00833	0.124	-0.0135	0.111
	(0.148)	(0.211)	(0.0663)	(0.151)
Employment share in mining and quarrying	0.408	-0.00862	-0.0513	0.0175
	(1.140)	(0.555)	(1.054)	(0.590)
Employment share in manufacturing	0.380**	-0.0940	0.269***	-0.0986
	(0.181)	(0.132)	(0.0887)	(0.180)
Employment share in services	-0.651***	-0.0511	-0.410***	-0.0459
	(0.140)	(0.308)	(0.100)	(0.250)
GDP in PPP per capita, log	6.444**	0.999	3.031*	0.456
	(2.727)	(3.437)	(1.711)	(2.610)
Employment growth in agriculture	-0.0130	-0.0311	-0.0206	-0.0351
	(0.0110)	(0.0226)	(0.0145)	(0.0257)
Employment growth in mining and quarrying	0.00240	0.00221	0.000563	0.00251
	(0.00363)	(0.00792)	(0.00261)	(0.00613)
Employment growth in manufacturing	0.0387*	-0.0280*	0.0744***	-0.0288
	(0.0208)	(0.0149)	(0.0165)	(0.0336)
Employment growth in services	-0.00614	-0.0247	-0.00587	-0.0343
	(0.0409)	(0.0498)	(0.0298)	(0.0492)
Spatially lagged characteristics:				
Unemployment rate	-0.285**	0.250	-0.104*	0.276**
	(0.112)	(0.230)	(0.0621)	(0.127)
Employment share in agriculture	0.549*	-1.110*	0.310*	-1.136***
	(0.293)	(0.629)	(0.187)	(0.425)
Employment share in mining and quarrying	-3.969	2.540	-3.233***	2.756
	(2.559)	(2.428)	(1.098)	(2.006)
Employment share in manufacturing	-0.0369	0.145	-0.00569	0.207
	(0.216)	(0.396)	(0.227)	(0.314)
Employment share in services	0.505**	-1.424**	0.249**	-1.437***
	(0.230)	(0.613)	(0.122)	(0.498)
GDP in PPP per capita, log	-0.981	7.639	0.719	8.174***
	(2.218)	(6.130)	(1.965)	(2.498)
Employment growth in agriculture	-0.0708**	-0.101*	-0.0797**	-0.114
	(0.0280)	(0.0548)	(0.0313)	(0.0716)
Employment growth in mining and quarrying	-0.00590	-0.0185	-0.00599	-0.0192
	(0.00733)	(0.0142)	(0.00501)	(0.0175)
Employment growth in manufacturing	0.0243	0.117*	0.0726*	0.147*
	(0.0273)	(0.0662)	(0.0431)	(0.0856)
Employment growth in services	0.273***	0.0119	0.135***	-0.0111
	(0.0857)	(0.154)	(0.0464)	(0.112)
Observations	3,155	563	3,127	561
Number of regions	189	32	189	32
Region-FE	Y	Y	Y	Y

Notes: Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1
'carbon' relates to carbon-intensive EU NUTS-2 regions, as defined in chapter 2. Columns (1) and (2) report the results for the least squares estimation, while columns (3) and (4) show the results for the bias-corrected least squares dummy variable estimation. The spatially lagged characteristics are calculated by considering the eight nearest neighbours. Robust standard errors in parentheses.

4.2. HIERARCHICAL SPECIFICATION WITH PANEL DATA

In the specifications presented above, we use the entire dataset at the NUTS-2 level. However, migration dynamics tend to be considerably different within NUTS-2 regions (European Commission, 2021). It is therefore important to analyse the main determinants of mobility patterns at a more granular level. This allows us to provide further insights into heterogeneous effects on the net migration rate between carbon-intensive regions and non-carbon-intensive regions, and additionally to test the robustness of our previous results. Unfortunately, information about the entire set of covariables is not available at the NUTS-3 level. For this reason, we employ a hierarchical model where the dependent variable is the net migration rate of NUTS-3 regions, and the covariates are defined at the NUTS-3 as well as the NUTS-2 level. The share of the population aged between 35-54, the share of highly educated individuals and the regional unemployment rate are available only at the NUTS-2 level and are therefore introduced as higher-level covariates. All other variables are reported at the NUTS-3 level. However, the employment structure and sectoral employment growth are accessible only at a more aggregated level. At the NUTS-3 level, we distinguish between employment in agriculture (A); mining/quarrying, manufacturing and supply (B-E); and services (G-J). In order to account for the hierarchical structure in the data, we include regional fixed effects at the NUTS-2 level and standard errors are clustered by NUTS-2 level regions. In total, we consider 980 NUTS-3 regions clustered in 196 NUTS-2 non-carbon-intensive regions, and 174 NUTS-3 regions clustered in 33 NUTS-2 carbon-intensive regions.

Table 7 in the Appendix summarises the estimation results for the baseline specification of the hierarchical model considering total employment growth. The results are structured into two panels: the results for the regional characteristics at the NUTS-3 level and the results for the regional characteristics at the NUTS-2 level. Overall, the results are much in line with the results presented above. The effect of the time-lagged migration rate tends to be more important for non-carbon-intensive regions than for carbon-intensive regions. Moreover, we find a positive effect for total employment growth in non-carbon-intensive regions, but no statistically significant effect for carbon-intensive ones. Interestingly, contrary to our results above, the share of highly educated individuals, as defined at the NUTS-2 level, shows a negative impact for both groups of regions. However, the effect tends to be larger in carbon-intensive regions.[2] Therefore, considering this variable as a proxy for the region's attractiveness and long-term potential, the results again suggest that carbon-intensive regions seem to be less attractive than non-carbon-intensive regions. The results for the NUTS-2 level unemployment rate suggest a negative effect on the net migration rate of its NUTS-3 regions for both non-carbon-intensive regions and carbon-intensive ones. These results indicate that labour markets are connected within NUTS-2 regions in both groups of regions.

The results for the specification with sectoral employment growth in Table 8 in the Appendix are also in line with previous findings. Unlike in non-carbon-intensive regions, we find only a weak positive effect from employment dynamics in mining/quarrying, manufacturing and supply on the net migration of carbon-intensive regions.

Table 9 and Table 10 in the Appendix further present the estimation results for the hierarchical model incorporating spatially lagged variables. Importantly, spatially lagged covariates at the NUTS-2 level are

2 When we estimate the specification using the total sample and introducing an interaction term between the share of the highly educated and a dummy indicating carbon-intensive regions, the interaction term is close to being statistically significant.

calculated based on the eight nearest neighbouring NUTS-2 level regions, while spatially lagged covariates at the NUTS-3 level are computed based on the eight nearest neighbouring NUTS-3 level regions, irrespective of whether these are non-carbon-intensive or carbon-intensive. As can be seen, economic factors of neighbouring regions tend to have only a weak effect on the net migration rates of both carbon-intensive regions and non-carbon-intensive regions.

4.3. LONGER-TERM DYNAMICS USING CROSS-SECTIONAL DATA

In the previous sections, we primarily use panel data that capture the yearly changes in the considered variables. In order to focus explicitly on longer-term dynamics in our specification, we further apply cross-sectional data that refer to dynamics within the period 2000-2018. As we have only 33 NUTS-2 level carbon-intensive regions, we again combine the NUTS-3 and NUTS-2 levels and employ a hierarchical model. At the NUTS-2 level, we include the share of the population aged between 35-54, the share of highly educated individuals, and the regional unemployment rate. Initial values are taken from 2000, while the dependent variable and all growth variables refer to the average growth rate over the period 2000-2018. As an additional explanatory variable, the cross-sectional specifications incorporate a regional accessibility variable, i.e. the road transport performance taken from Eurostat for 2011. In order to account for the data hierarchy in the specification, we cluster the standard errors by NUTS-2 level.

Table 11 in the Appendix shows the results of the baseline cross-sectional model. Columns (1) and (2) consider the regional total employment growth, while columns (3) and (4) present the results using regional sectoral employment growth rates. The first panel lists the results for the covariates at the NUTS-3 level, while the second panel lists those at the NUTS-2 level. Consistent with the results presented above, the estimated effects of the population density suggest congestion costs that negatively affect the net migration rate of regions. In both types of regions, the dominance of the service industry seems to be important for migration dynamics. A higher share of employed individuals in the service industry is associated with a higher net inflow from other regions. In line with our previous findings, the regional welfare level, as captured by the initial GDP per capita level, appears in both groups of regions to act as a pull factor for migration. Our regional accessibility indicator suggests similar effects in carbon-intensive and non-carbon-intensive regions. Easier accessibility to a NUTS-3 region is typically associated with higher net inflows of individuals. Interestingly, we find similar effects for the regional total employment growth. For both types of region, prospects of employment and income seem to increase the propensity to move there. However, importantly, the effect is smaller in carbon-intensive regions than in non-carbon-intensive regions.

We also estimated a specification for the total sample (pooling carbon-intensive and non-carbon-intensive regions) and included an interaction term between total employment growth and a dummy variable indicating carbon-intensive regions. The negative estimated coefficient of the interaction term tended to be statistically different from zero. We also observe differences between the two groups of regions in the results for the sectoral employment growth (see columns (3) and (4)). Although employment growth in the service sector seems positively to affect migration in both cases, the results for the other industries point to heterogeneous effects. Regarding the explanatory variables at the NUTS-2 level, we find that the unemployment rate exerts a nearly equal negative impact on net migration in both carbon-intensive regions and non-carbon-intensive regions, and the share of highly educated individuals is shown to have a statistically significant effect in carbon-intensive regions, but not in non-carbon-intensive ones. These findings point to conclusions that are in accordance with those discussed above, i.e. that carbon-intensive regions seem to be less attractive with respect to migration flows.

Analogous to our above procedure, we augment the cross-sectional hierarchical model and consider economic factors of neighbouring regions as additional covariates to account for local economic spillover effects (see Table 12 in the Appendix). The spatially lagged characteristics are calculated by considering the eight nearest neighbours of each NUTS-3 region and each NUTS-2 region, respectively. The estimation results of the region-specific characteristics (see the first panel of Table 12) are consistent with the findings reported in Table 11. The estimation results for the spatially lagged economic factors are presented in the second panel of Table 12. The economic structure of neighbouring regions tends to impact migration dynamics in non-carbon-intensive regions. Also, in line with our previous findings, employment dynamics in neighbouring regions tend to play a greater role in non-carbon-intensive regions. Overall, economic factors of neighbouring regions are revealed to be less relevant for migration patterns in carbon-intensive regions.

As a further robustness check, we additionally estimate the cross-sectional specifications by incorporating NUTS-2 level fixed effects. This allows us to control for overall region-specific differences at the NUTS-2 level. Thus, all variables in these specifications are introduced at the NUTS-3 level. The results are presented in Table 13 and Table 14 in the Appendix. The estimated coefficients are in line with those presented in Table 11 and Table 12 in the Appendix.

4.4. ANALYSING SPATIAL HETEROGENEITY USING GEOGRAPHICALLY WEIGHTED REGRESSION

The global results show a consistent picture of the drivers of regional migration. However, it is reasonable to assume that, given the inherent differences between regions in terms of their economic, social and geographic characteristics, the impact of these drivers differs territorially as some of them may have greater impacts in certain types of regions than in others. To check for patterns of spatial heterogeneity of the migration drivers, we employ, as a final step, geographically weighted regression (GWR) to the NUTS-3 level data.

GWR is a type of model where the estimated coefficients are not global solutions, but depend on the geographic location of the respective region. It is based on locally linear regressions, based on a Gaussian principle in which those regions that are the closest to the regression region have greater weights than the other regions. It uses the hypothesis that the geographically closer two regions are, the more similar is the influence of the explanatory variables on the dependent variable. More formally, the GWR model is defined as :

$$y_r = \beta_0(u_r, v_r) + \sum_s \beta_s(u_r, v_r)\, x_{rs} + \varepsilon_i$$

where (u_r, v_r) are the geographical co-ordinates of region r and $\beta_s(u_r, v_r)$ is the estimated coefficient in region r; x_{rs} represents the explanatory variables. The estimated coefficients are therefore a function of the regions' location, rather than an average value over all regions. Importantly, in the estimation of the coefficients, those regions that are closer to the estimation point have a higher weight than more distant regions. Therefore, the choice of these distance weights is crucial for the regression results and their interpretation (Fábián, 2014).

To define the distance weights, we use a distance matrix W(u_r, v_r) that contains the weight of each region according to its distance to region r with the co-ordinates (u_r, v_r). Accordingly, the weight of the regions decreases in line with their distance to region r. In our model, this decrease in weights is specified via a fixed, bi-square kernel function, in which the extent of the kernel is determined by the distance to the region at the centre of each local regression. Also, for each region, the kernel is identical.

A key parameter for the kernel function is the bandwidth, i.e. the distance beyond which regions have zero influence on the region at the centre of the respective regression. Generally, the larger the bandwidth, the more regions are given non-zero weights and the smoother the geographic distribution of estimated coefficients will be. In the model, we choose the optimal bandwidth using the automatic bandwidth selection function in the R 'GWmodel' package.

We re-estimate the two cross-sectional models (without spatially lagged variables) of long-run migration dynamics outlined above, by using robust GWR, which is less sensitive to outliers. Also, to test the validity of the GWR model, we perform a Monte Carlo simulation-type test to test for spatial stationarity of the explanatory variables, testing the hypothesis as to whether the estimated coefficients are constant over the NUTS-3 regions.

As far as the GWR results are concerned, it is important to keep in mind that the coefficients were estimated using a fixed-distance bandwidth. This implies that the number of observations (i.e. neighbouring regions) for each regression tends to differ across regional estimates. In particular, the regressions regarding island regions, or regions in northern Sweden and Finland, may have a low number of observations, which reduces the reliability of the results for those regions.

Looking first at the distribution of GWR coefficients for the explanatory variables across carbon-intensive and non-carbon-intensive regions, they are illustrated in the box and whisker plots in Figure 6 to Figure 11 in the Appendix. The GWR results are highly consistent with the cross-section estimates above. Thus, on average, GDP per capita has a higher impact on migration in carbon-intensive regions than in non-carbon-intensive regions. Likewise, aggregate employment growth tends to be a stronger pull factor in non-carbon-intensive regions than in others. The other explanatory variables also tend to follow a similar pattern.

The more interesting question is whether there is a spatial heterogeneity in the estimated coefficients. The results of the stationarity tests (see Table 6) indicate the rejection of the H0 of no spatial stationarity for all explanatory variables except population density and the employment share, as well as employment growth in mining and quarrying, manufacturing, and energy supply.

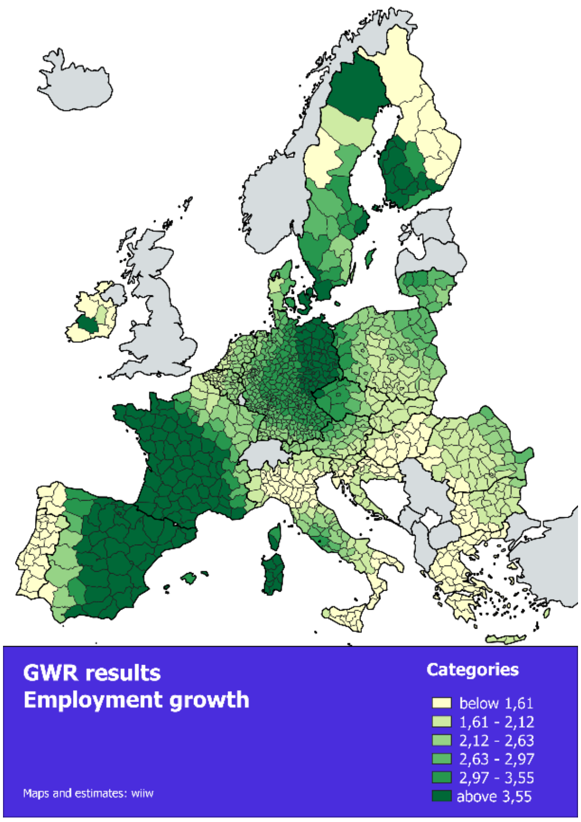
Table 6 / Tests for spatial stationarity

Dependent variable:	**p-value**
Region's characteristics:	
Active population, log	0.29
Population density	0.00
Employment share in agriculture	0.29
Employment share in mining and quarrying, manufacturing, and energy supply	0.06
Employment share in services	0.21
GDP in PPP per capita, log	0.18
Road transport performance	0.66
Avg. employment growth	0.13
Avg. employment growth in agriculture	0.12
Avg. employment growth in mining/quarrying, manufacturing, and energy supply	0.06
Avg. employment growth in services	0.25

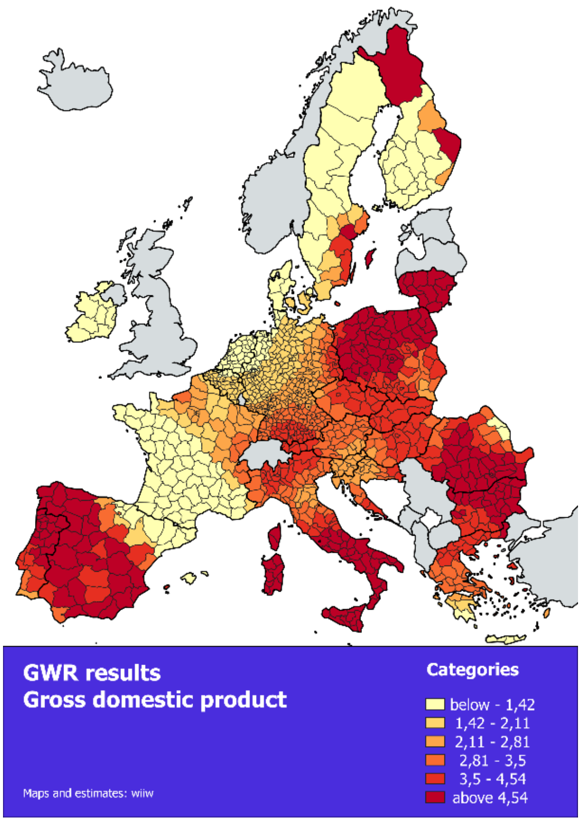
Notes: The coefficients for active population were insignificant at the global level.

Figure 5 / Estimated territorial coefficients of the effects of employment growth and initial GDP on migration, in %

(a) Employment growth



(b) Initial GDP



Source: wiiw maps and estimations.

To illustrate the extent of spatial heterogeneity in the estimated coefficients, Figure 5 shows the estimated regional coefficients for the effects of employment growth and initial GDP on regional migration (the other estimates are provided in the Appendix).[3]

As far as employment growth is concerned, the GWR results indicate that it is an important pull factor for migration in all EU NUTS-3 regions. The strength of the pull tends to differ across regions, however. As Figure 5 shows, it is particularly strong in central and eastern Spain, western France and eastern Germany and weaker in Portugal, and parts of Central Europe including Austria, Hungary, Slovakia, Poland, Romania, Bulgaria and northern Italy.

As far as initial GDP is concerned, it is also a pull factor in all regions, but foremost in the mostly less developed regions in Poland, Romania, Bulgaria, Spain, Portugal and southern Italy. This indicates an urbanisation trend in those regions; usually, the regions with the highest GDP (and thus the more attractive for inward migration) are urban centres.

3 For the variables that were significant in the cross-sectional analysis, and that show spatial heterogeneity.

5. Conclusions

The analysis revealed two important results. First, unlike in non-carbon-intensive regions, employment growth is not a driver of migration in carbon-intensive regions in the EU. Second, the estimated negative impact of the share of highly educated individuals on migration in carbon-intensive regions suggests that these regions are comparatively unattractive for the highly educated, and thus suffer from brain drain. Additionally, in carbon-intensive regions, low levels of GDP are associated with higher net emigration. Together, these two results point strongly to a general unattractiveness of carbon-intensive regions, particularly in Central and Eastern Europe, as these are the ones experiencing net migration outflows.

From a strategic point of view, it therefore does not seem adequate for those regions to compensate for potential employment losses in carbon-intensive sectors through the creation of new jobs. According to the results, this will not necessarily stop outward migration. Instead, employment-creating policy measures need to be accompanied by a set of measures to improve the general attractiveness of such regions. In our results, this is, for example, indicated by the positive effect of the regions' transport performance on migration. Hence infrastructure – i.e. not simply connecting the regions to main European transport networks, but also connecting the hinterland within the regions – is one of the factors that policy may look into. Also relevant are social factors, such as the provision of social services, including health and education, or aspects of well-being and standards of living (in which economic prosperity, although important, is not the only factor to consider).

Therefore, we argue that, in order to increase the attractiveness of carbon-intensive regions, policy makers need to adopt an integrated approach, tackling not only the employment challenge that may occur through the decline in carbon-intensive industries, but simultaneously also the other challenges to those regions' attractiveness, such as accessibility, provision of social services, levels of economic prosperity, environmental problems etc. It is thus also recommended to analyse those challenges to the carbon-intensive regions, particularly in Central and Eastern Europe, in more detail; to identify the main challenges; and to develop policy concepts at the European level, supported by national and regional levels, in order to address these challenges through a policy package of integrated measures.

References

Brunsdon, C., S. Fotheringham and M. Charlton (1998), 'Geographically weighted regression – modelling spatial non-stationarity', *Journal of the Royal Statistical Society, Series D: The Statistician*, Vol. 47(3), pp. 431-443.

Buch, T., S. Hamann, A. Niebuhr and A. Rossen (2014), 'What makes cities attractive? The determinants of urban labour migration in Germany', *Urban Studies*, Vol. 51(9), pp. 1960-1978.

Corrado, L. and B. Fingleton (2012), 'Where is the economics in spatial econometrics?', *Journal of Regional Science*, Vol. 52(2), pp. 210-239.

Etzo, I. (2011), 'The determinants of the recent interregional migration flows in Italy: a panel data analysis', *Journal of Regional Science*, Vol. 51(5), pp. 948-966.

EU (2021), 'Regulation (EU) 2021/1119 of the European Parliament and of the Council of 30 June 2021 establishing the framework for achieving climate neutrality and amending Regulations (EC) No 401/2009 and (EU) 2018/1999 ("European Climate Law")'.

European Commission (2019), 'The European Green Deal, COM(2019) 640 final'.

European Commission (2020a), 'Impact assessment accompanying the Communication "Stepping up Europe's 2030 climate ambition: investing in a climate-neutral future for the benefit of our people", SWD(2020) 176 final'.

European Commission (2020b), 'Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions "Stepping up Europe's 2030 climate ambition: investing in a climate-neutral future for the benefit of our people", COM (2020) 562 final'.

European Commission (2021), 'Cohesion in Europe towards 2050. Eigth report on economic, social and territorial cohesion'.

Fábián, Z. (2014), 'Method of the geographically weighted regression and an example for its application', *Regional Statistics*, Vol. 4(1), pp. 61-75.

Kiviet, J.F. (1995), 'On bias, inconsistency, and efficiency of various estimators in dynamic panel data models', *Journal of Econometrics*, Vol. 68(1), pp. 53-78.

LeSage, J. and R.K. Pace (2009), *Introduction to Spatial Econometrics*, Chapman and Hall/CRC, New York.

Rodríguez-Pose, A. and T.D. Ketterer (2012), 'Do local amenities affect the appeal of regions in Europe for migrants?', *Journal of Regional Science*, Vol. 52(4), pp. 535-561.

Sardadvar, S. and E. Vakulenko (2017), 'A model of interregional migration under the presence of natural resources: theory and evidence from Russia'. *The Annals of Regional Science*, Vol. 59(2), pp. 535-569.

Shayegh, S. (2017), 'Outward migration may alter population dynamics and income inequality', *Nature Climate Change*, Vol. 7(11), pp. 828-832.

Vega, S.H. and J.P. Elhorst (2013), 'On spatial econometric models, spillover effects, and W', *ERSA Conference Papers*, ersa13p222, European Regional Science Association (paper presented at 53rd ERSA Congress, Palermo, Italy, 27-31 August).

Appendix

Table 7 / Baseline hierarchical panel model (NUTS-3 and NUTS-2 levels)

Dependent variable:	**Net migration rate**			
Subgroup:	**non-carbon**	**carbon**	**non-carbon**	**carbon**
	(1)	**(2)**	**(3)**	**(4)**
NUTS-3 level characteristics:				
Lagged net migration rate	-	-	0.446***	0.181**
	(-)	(-)	(0.0586)	(0.0840)
Active population, log	-0.0182	0.406	-0.0201	0.317
	(0.267)	(0.379)	(0.132)	(0.317)
Population density	-0.000696**	-0.00141***	-0.000380**	-0.00118**
	(0.000278)	(0.000492)	(0.000147)	(0.000509)
Employment share in agriculture	0.0148	0.124**	0.0166	0.110**
	(0.0351)	(0.0591)	(0.0203)	(0.0532)
Employment share in mining/quarrying, manufacturing, and supply	-0.0638***	-0.00692	-0.0285**	-0.000388
	(0.0204)	(0.0437)	(0.0123)	(0.0363)
Employment share in services	0.179***	0.295***	0.104***	0.251**
	(0.0544)	(0.0944)	(0.0305)	(0.0932)
GDP in PPP per capita, log	3.350***	6.124***	1.998***	5.238***
	(0.508)	(0.947)	(0.413)	(1.192)
Employment growth	0.226***	0.0409	0.154***	0.0143
	(0.0593)	(0.0626)	(0.0457)	(0.0635)
NUTS-2 level characteristics:				
Share of population aged 35-54	-0.708***	-0.640***	-0.405***	-0.599***
	(0.0899)	(0.170)	(0.0781)	(0.138)
Share of highly educated population	-0.170***	-0.378***	-0.0868***	-0.317***
	(0.0449)	(0.0925)	(0.0285)	(0.0883)
Unemployment rate	-0.446***	-0.321***	-0.227***	-0.239***
	(0.0602)	(0.100)	(0.0384)	(0.0862)
Observations	16,207	3,051	15,880	3,012
Number of NUTS-2 regions	196	33	196	33
NUTS-2 region-FE	Y	Y	Y	Y

Notes: Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1
'carbon' relates to carbon-intensive EU NUTS-2/NUTS-3 regions, as defined in chapter 2. The dependent variable is defined at the NUTS-3 level, while explanatory variables are considered at the NUTS-3 level and NUTS-2 level. All estimations include a constant (not shown in the table) and region fixed effects at the NUTS-2 level. Standard errors are clustered by NUTS-2 level.

Table 8 / Baseline hierarchical panel model (NUTS-3 and NUTS-2 levels), sectoral employment growth

Dependent variable:	Net migration rate			
Subgroup:	non-carbon (1)	carbon (2)	non-carbon (3)	carbon (4)
NUTS-3 level characteristics:				
Lagged net migration rate	-	-	0.449***	0.184**
	(-)	(-)	(0.0586)	(0.0839)
Active population, log	-0.0341	0.384	-0.0304	0.288
	(0.268)	(0.379)	(0.131)	(0.313)
Population density	-0.000697**	-0.00136***	-0.000372**	-0.00111**
	(0.000277)	(0.000489)	(0.000144)	(0.000505)
Employment share in agriculture	0.00611	0.119**	0.00857	0.106**
	(0.0347)	(0.0576)	(0.0199)	(0.0508)
Employment share in mining/quarrying, manufacturing, and supply	-0.0620***	-0.00542	-0.0270**	0.00215
	(0.0205)	(0.0442)	(0.0124)	(0.0362)
Employment share in services	0.192***	0.304***	0.112***	0.259***
	(0.0559)	(0.0956)	(0.0314)	(0.0940)
GDP in PPP per capita, log	3.422***	6.022***	2.023***	5.083***
	(0.503)	(0.934)	(0.410)	(1.180)
Employment growth in agriculture	-5.20e-05***	-0.00936	-0.00305	-0.0122
	(2.85e-06)	(0.0137)	(0.00665)	(0.0144)
Employment growth in mining/quarrying, manufacturing, and supply	0.0236	0.0349	0.0461***	0.0434*
	(0.0143)	(0.0264)	(0.0110)	(0.0224)
Employment growth in services	0.118***	0.0573	0.0764***	0.0543
	(0.0326)	(0.0447)	(0.0258)	(0.0471)
NUTS-2 level characteristics:				
Share of population aged 35-54	-0.721***	-0.642***	-0.401***	-0.597***
	(0.0921)	(0.165)	(0.0789)	(0.127)
Share of highly educated population	-0.173***	-0.382***	-0.0892***	-0.321***
	(0.0451)	(0.0912)	(0.0285)	(0.0868)
Unemployment rate	-0.449***	-0.324***	-0.230***	-0.243***
	(0.0615)	(0.0973)	(0.0384)	(0.0813)
Observations	16,188	3,049	15,861	3,010
Number of NUTS-2 regions	196	33	196	33
NUTS-2 region-FE	Y	Y	Y	Y

Notes: Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1
'carbon' relates to carbon-intensive EU NUTS-2/NUTS-3 regions, as defined in chapter 2. The dependent variable is defined at the NUTS-3 level, while explanatory variables are considered at the NUTS-3 level and NUTS-2 level. All estimations include a constant (not shown in the table) and region fixed effects at the NUTS-2 level. Standard errors are clustered by NUTS-2 level.

Table 9 / Baseline hierarchical panel model (NUTS-3 and NUTS-2 levels), with spatially lagged variables

Dependent variable:	Net migration rate			
Subgroup:	non-carbon (1)	carbon (2)	non-carbon (3)	carbon (4)
Own characteristics: **NUTS-3 level characteristics:**				
Lagged net migration rate	-	-	0.446***	0.166*
	(-)	(-)	(0.0588)	(0.0875)
Active population, log	-0.0127	0.475	-0.00857	0.394
	(0.274)	(0.318)	(0.135)	(0.275)
Population density	-0.000702**	-0.00111**	-0.000384**	-0.000958**
	(0.000283)	(0.000429)	(0.000151)	(0.000432)
Employment share in agriculture	0.0177	0.128**	0.0195	0.115**
	(0.0353)	(0.0572)	(0.0208)	(0.0535)
Employment share in mining/quarrying, manufacturing, and supply	-0.0657***	0.000996	-0.0294**	0.00501
	(0.0199)	(0.0486)	(0.0125)	(0.0410)
Employment share in services	0.182***	0.300***	0.106***	0.256**
	(0.0548)	(0.0946)	(0.0302)	(0.0957)
GDP in PPP per capita, log	3.349***	5.388***	2.000***	4.684***
	(0.509)	(0.806)	(0.403)	(1.010)
Employment growth	0.210***	0.00763	0.137***	-0.0161
	(0.0482)	(0.0649)	(0.0374)	(0.0712)
NUTS-2 level characteristics:				
Share of population aged 35-54	-0.705***	-0.635***	-0.405***	-0.613***
	(0.0942)	(0.193)	(0.0817)	(0.163)
Share of highly educated population	-0.150**	-0.530***	-0.0698*	-0.457***
	(0.0599)	(0.118)	(0.0382)	(0.136)
Unemployment rate	-0.402***	-0.263**	-0.202***	-0.191
	(0.0976)	(0.124)	(0.0573)	(0.116)
Spatially lagged characteristics: **NUTS-3 level characteristics:**				
Employment share in agriculture	-0.0144	-0.143	0.0358	-0.0970
	(0.0745)	(0.166)	(0.0427)	(0.151)
Employment share in mining/quarrying, manufacturing, and supply	0.0515	-0.117	0.0654*	-0.0698
	(0.0596)	(0.106)	(0.0362)	(0.0978)
Employment share in services	0.0246	-0.386	0.0584	-0.289
	(0.0946)	(0.268)	(0.0543)	(0.257)
GDP in PPP per capita, log	-0.338	4.387**	0.0550	4.027**
	(1.467)	(1.777)	(0.830)	(1.866)
Employment growth	0.0450	0.0907	0.0466	0.0944
	(0.0767)	(0.130)	(0.0777)	(0.134)
NUTS-2 level characteristics:				
Unemployment rate	-0.0649	0.00628	-0.0335	0.00813
	(0.102)	(0.165)	(0.0619)	(0.145)
Observations	16,207	3,051	15,880	3,012
Number of NUTS-2 regions	196	33	196	33
NUTS-2 region-FE	Y	Y	Y	Y

Notes: Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1
'carbon' relates to carbon-intensive EU NUTS-2/NUTS-3 regions, as defined in chapter 2. The dependent variable is defined at the NUTS-3 level, while explanatory variables are considered at the NUTS-3 level and NUTS-2 level. All estimations include a constant (not shown in the table) and region fixed effects at the NUTS-2 level. The spatially lagged characteristics are calculated by considering the eight nearest neighbours of the NUTS-3 and NUTS-2 regions, respectively. Standard errors are clustered by NUTS-2 level.

Table 10 / Baseline hierarchical panel model (NUTS-3 and NUTS-2 levels), with spatially lagged variables, sectoral employment growth

Dependent variable:	Net migration rate			
Subgroup:	non-carbon (1)	carbon (2)	non-carbon (3)	carbon (4)
Own characteristics:				
NUTS-3 level characteristics:				
Lagged net migration rate	-	-	0.450***	0.168*
	(-)	(-)	(0.0594)	(0.0871)
Active population, log	-0.0217	0.433	-0.0126	0.354
	(0.276)	(0.309)	(0.134)	(0.264)
Population density	-0.000703**	-0.00104**	-0.000379**	-0.000882**
	(0.000282)	(0.000428)	(0.000149)	(0.000426)
Employment share in agriculture	0.0106	0.121**	0.0128	0.109**
	(0.0346)	(0.0557)	(0.0200)	(0.0508)
Employment share in mining/quarrying, manufacturing, and supply	-0.0642***	0.00321	-0.0279**	0.00775
	(0.0200)	(0.0493)	(0.0124)	(0.0412)
Employment share in services	0.194***	0.308***	0.113***	0.262**
	(0.0562)	(0.0953)	(0.0309)	(0.0960)
GDP in PPP per capita, log	3.408***	5.222***	2.004***	4.510***
	(0.506)	(0.794)	(0.404)	(0.981)
Employment growth in agriculture	-5.08e-05***	-0.0203	-0.00287	-0.0210
	(4.10e-06)	(0.0166)	(0.00665)	(0.0176)
Employment growth in mining/quarrying, manufacturing, and supply	0.0174	0.0523**	0.0268***	0.0465**
	(0.0109)	(0.0194)	(0.00951)	(0.0176)
Employment growth in services	0.104***	0.0477	0.0624**	0.0430
	(0.0295)	(0.0439)	(0.0257)	(0.0493)
NUTS-2 level characteristics:				
Share of population aged 35-54	-0.716***	-0.663***	-0.390***	-0.628***
	(0.0971)	(0.188)	(0.0853)	(0.154)
Share of highly educated population	-0.155***	-0.525***	-0.0756**	-0.459***
	(0.0593)	(0.119)	(0.0380)	(0.135)
Unemployment rate	-0.399***	-0.263**	-0.201***	-0.200*
	(0.0993)	(0.120)	(0.0573)	(0.108)
Spatially lagged characteristics:				
NUTS-3 level characteristics:				
Employment share in agriculture	-0.0163	-0.132	0.0241	-0.0905
	(0.0768)	(0.166)	(0.0443)	(0.148)
Employment share in mining/quarrying, manufacturing, and supply	0.0581	-0.113	0.0699*	-0.0638
	(0.0593)	(0.106)	(0.0360)	(0.0970)
Employment share in services	0.0353	-0.359	0.0647	-0.270
	(0.0934)	(0.277)	(0.0542)	(0.262)
GDP in PPP per capita, log	-0.223	4.432**	0.00756	4.048**
	(1.447)	(1.769)	(0.805)	(1.875)
Employment growth in agriculture	-7.10e-05	0.0297*	-0.000108	0.0268
	(5.41e-05)	(0.0171)	(7.65e-05)	(0.0180)
Employment growth in mining/quarrying, manufacturing, and supply	0.00706	-0.0399	0.0740**	0.00739
	(0.0281)	(0.0523)	(0.0307)	(0.0453)
Employment growth in services	0.0591	0.00487	0.0268	-0.000582
	(0.0500)	(0.0814)	(0.0406)	(0.0695)
NUTS-2 level characteristics:				
Unemployment rate	-0.0718	0.00367	-0.0423	0.0116
	(0.103)	(0.164)	(0.0623)	(0.142)
Observations	16,188	3,049	15,861	3,010
Number of NUTS-2 regions	196	33	196	33
NUTS-2 region-FE	Y	Y	Y	Y

Notes: Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1
'carbon' relates to carbon-intensive EU NUTS-2/NUTS-3 regions, as defined in chapter 2. The dependent variable is defined at the NUTS-3 level, while explanatory variables are considered at the NUTS-3 level and NUTS-2 level. All estimations include a constant (not shown in the table) and region fixed effects at the NUTS-2 level. The spatially lagged characteristics are calculated by considering the eight nearest neighbours of the NUTS-3 and NUTS-2 regions, respectively. Standard errors are clustered by NUTS-2 level.

Table 11 / Hierarchical cross-sectional model (NUTS-3 and NUTS-2 levels)

Dependent variable:	**Avg. net migration rate**			
Subgroup:	**non-carbon**	**carbon**	**non-carbon**	**carbon**
	(1)	**(2)**	**(3)**	**(4)**
NUTS-3 level characteristics:				
Active population, log (2000)	-0.106	0.240	-0.226	0.133
	(0.218)	(0.231)	(0.249)	(0.191)
Population density (2000)	-0.000776***	-0.00114***	-0.000822***	-0.00128***
	(0.000110)	(0.000316)	(0.000119)	(0.000308)
Employment share in agriculture (2000)	-0.00783	0.147***	-0.0994***	0.0871**
	(0.0266)	(0.0290)	(0.0279)	(0.0340)
Employment share in mining/quarrying, manufacturing, and supply (2000)	-0.0842***	0.0135	-0.0940***	0.00662
	(0.0221)	(0.0244)	(0.0235)	(0.0311)
Employment share in services (2000)	0.0577	0.316***	0.131**	0.396***
	(0.0568)	(0.0690)	(0.0591)	(0.0745)
GDP in PPP per capita, log (2000)	2.169***	3.908***	2.649***	3.851***
	(0.546)	(0.649)	(0.589)	(0.495)
Road transport performance (2011)	0.0236**	0.0287***	0.0234**	0.0296***
	(0.0102)	(0.0104)	(0.0102)	(0.0101)
Avg. employment growth	2.856***	1.406***	-	-
	(0.319)	(0.299)	(-)	(-)
Avg. employment growth in agriculture	-	-	-5.69e-05	-0.130***
	(-)	(-)	(0.000106)	(0.0431)
Avg. employment growth in mining/quarrying, manufacturing, and supply	-	-	0.310***	-0.0675
	(-)	(-)	(0.118)	(0.100)
Avg. employment growth in services	-	-	1.641***	1.330***
	(-)	(-)	(0.276)	(0.145)
NUTS-2 level characteristics:				
Share of population aged 35-54 (2000)	-0.440***	0.173	-0.345***	0.253***
	(0.0968)	(0.137)	(0.107)	(0.0772)
Share of highly educated population (2000)	-0.0333	-0.0809*	-0.0393	-0.0623**
	(0.0464)	(0.0398)	(0.0629)	(0.0297)
Unemployment rate (2000)	-0.106***	-0.195***	-0.125***	-0.196***
	(0.0365)	(0.0443)	(0.0369)	(0.0312)
Observations	937	174	937	174
NUTS-2 region-FE	Y	Y	Y	Y

Notes: Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1
‘carbon’ relates to carbon-intensive EU NUTS-2 regions, as defined in chapter 2. All specifications cover the time period 2000-2018. Initial values for covariates at the NUTS-2 and NUTS-3 level are taken from 2000, while dependent variable and growth variables relate to the average growth rate over the period 2000-2018. Standard errors are clustered by NUTS-2 level. The spatially lagged characteristics are calculated by considering the eight nearest neighbours of each NUTS-3 region and NUTS-2 region, respectively.

Table 12 / Hierarchical cross-sectional model (NUTS-3 and NUTS-2 levels) with spatially lagged variables

Dependent variable:	Avg. net migration rate			
Subgroup:	non-carbon	carbon	non-carbon	carbon
	(1)	(2)	(3)	(4)
Own characteristics:				
NUTS-3 level characteristics:				
Active population, log (2000)	-0.141	0.272	-0.374	0.231
	(0.217)	(0.239)	(0.266)	(0.222)
Population density (2000)	-0.000716***	-0.00105***	-0.000760***	-0.00110***
	(0.000100)	(0.000334)	(0.000105)	(0.000315)
Employment share in agriculture (2000)	0.00464	0.152***	-0.0750**	0.102***
	(0.0287)	(0.0329)	(0.0309)	(0.0352)
Employment share in mining/quarrying, manufacturing, and supply (2000)	-0.0636***	0.0143	-0.0786***	0.0130
	(0.0196)	(0.0303)	(0.0202)	(0.0374)
Employment share in services (2000)	0.109*	0.316***	0.183***	0.399***
	(0.0572)	(0.0758)	(0.0637)	(0.0795)
GDP in PPP per capita, log (2000)	2.287***	3.659***	2.780***	3.696***
	(0.495)	(0.602)	(0.523)	(0.471)
Road transport performance (2011)	0.0206*	0.0248**	0.0233**	0.0173
	(0.0106)	(0.0120)	(0.0107)	(0.0131)
Avg. employment growth	2.642***	1.402***	-	-
	(0.363)	(0.325)	(-)	(-)
Avg. employment growth in agriculture	-	-	-0.000183	-0.130***
	(-)	(-)	(0.000162)	(0.0401)
Avg. employment growth in mining/quarrying, manufacturing, and supply	-	-	0.334**	-0.0723
	(-)	(-)	(0.137)	(0.112)
Avg. employment growth in services	-	-	1.480***	1.412***
	(-)	(-)	(0.232)	(0.161)
NUTS-2 level characteristics:				
Share of population aged 35-54 (2000)	-0.516***	0.170	-0.410***	0.163
	(0.102)	(0.210)	(0.116)	(0.160)
Share of highly educated population (2000)	-0.0406	-0.0748*	-0.0426	-0.0537*
	(0.0486)	(0.0415)	(0.0713)	(0.0286)
Unemployment rate (2000)	-0.157***	-0.190***	-0.125**	-0.189***
	(0.0515)	(0.0556)	(0.0605)	(0.0426)
Spatially lagged characteristics:				
NUTS-3 level characteristics:				
GDP in PPP per capita, log (2000)	-0.565	0.449	-0.612	-0.798
	(1.171)	(1.280)	(1.308)	(1.182)
Employment share in agriculture (2000)	-0.0499	-0.00118	-0.0886*	-0.0856
	(0.0471)	(0.0574)	(0.0534)	(0.0619)
Employment share in mining/quarrying, manufacturing, and supply (2000)	-0.0638	0.0146	-0.0380	-0.0213
	(0.0461)	(0.0505)	(0.0446)	(0.0549)
Employment share in services (2000)	-0.157**	0.0643	-0.158**	0.0225
	(0.0733)	(0.116)	(0.0757)	(0.112)
Avg. employment growth	0.885*	-0.188	-	-
	(0.507)	(0.739)	(-)	(-)
Avg. employment growth in agriculture	-	-	0.00337**	-0.00902
	(-)	(-)	(0.00135)	(0.126)
Avg. employment growth in mining/quarrying, manufacturing, and supply	-	-	-0.0462	-0.177
	(-)	(-)	(0.267)	(0.359)
Avg. employment growth in services	-	-	0.826*	0.402
	(-)	(-)	(0.499)	(0.601)
NUTS-2 level characteristics:				
Unemployment rate (2000)	0.0733	0.0301	-0.0218	-0.0353
	(0.0805)	(0.0973)	(0.0919)	(0.102)
Observations	937	174	937	174
NUTS-2 region-FE	Y	Y	Y	Y

Notes: Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1
'carbon' relates to carbon-intensive EU NUTS-2 regions, as defined in chapter 2. All specifications cover the time period 2000-2018. Initial values for covariates at the NUTS-2 and NUTS-3 level are taken from 2000, while dependent variable and growth variables relate to the average growth rate over the period 2000-2018. Standard errors are clustered by NUTS-2 level. The spatially lagged characteristics are calculated by considering the eight nearest neighbours of each NUTS-3 region and NUTS-2 region, respectively.

Table 13 / Cross-sectional model (NUTS-3 level with NUTS-2 regional fixed effects)

Dependent variable:	Avg. net migration rate			
Subgroup:	non-carbon (1)	carbon (2)	non-carbon (3)	carbon (4)
Active population, log (2000)	-0.870***	-0.152	-0.822***	-0.173
	(0.227)	(0.398)	(0.240)	(0.449)
Population density (2000)	-0.000649**	-0.00110***	-0.000655**	-0.00119***
	(0.000262)	(0.000403)	(0.000258)	(0.000434)
Employment share in agriculture (2000)	0.000888	0.118**	-0.0568*	0.0615
	(0.0331)	(0.0455)	(0.0301)	(0.0461)
Employment share in mining/quarrying, manufacturing, and supply (2000)	-0.0654***	-0.0261	-0.0748***	-0.0380
	(0.0225)	(0.0410)	(0.0212)	(0.0434)
Employment share in services (2000)	0.116**	0.223**	0.173***	0.303***
	(0.0552)	(0.0948)	(0.0578)	(0.0986)
GDP in PPP per capita, log (2000)	2.279***	4.453***	2.781***	4.572***
	(0.485)	(0.987)	(0.542)	(0.880)
Road transport performance (2011)	0.0340***	0.0333**	0.0335***	0.0317*
	(0.0117)	(0.0149)	(0.0119)	(0.0162)
Avg. employment growth	2.564***	1.584***	-	-
	(0.402)	(0.379)	(-)	(-)
Avg. employment growth in agriculture	-	-	0.000261	-0.129*
	(-)	(-)	(0.000281)	(0.0636)
Avg. employment growth in mining/quarrying, manufacturing, and supply	-	-	0.283*	0.123
	(-)	(-)	(0.152)	(0.146)
Avg. employment growth in services	-	-	1.495***	1.299***
	(-)	(-)	(0.303)	(0.214)
Observations	975	174	975	174
NUTS-2 region-FE	Y	Y	Y	Y

Notes: Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1
'carbon' relates to carbon-intensive EU NUTS-2 regions, as defined in chapter 2. All specifications cover the time period 2000-2018. Initial values are taken from 2000, while dependent variable and growth variables relate to the average growth rate over the period 2000-2018. All specifications are estimated using NUTS-2 level fixed effects. Standard errors are clustered by NUTS-2 level.

Table 14 / Cross-sectional model (NUTS-3 level with NUTS-2 regional fixed effects) with spatially lagged variables

Dependent variable:	**Avg. net migration rate**			
Subgroup:	**non-carbon (1)**	**carbon (2)**	**non-carbon (3)**	**carbon (4)**
Own characteristics:				
Active population, log (2000)	-0.844***	-0.224	-0.759***	-0.178
	(0.230)	(0.412)	(0.240)	(0.439)
Population density (2000)	-0.000637**	-0.000970**	-0.000638**	-0.00115**
	(0.000258)	(0.000434)	(0.000250)	(0.000535)
Employment share in agriculture (2000)	0.0154	0.154***	-0.0476	0.104**
	(0.0350)	(0.0407)	(0.0311)	(0.0443)
Employment share in mining/quarrying, manufacturing, and supply (2000)	-0.0527**	0.00645	-0.0661***	-0.00545
	(0.0238)	(0.0401)	(0.0217)	(0.0449)
Employment share in services (2000)	0.131**	0.286***	0.186***	0.370***
	(0.0570)	(0.100)	(0.0599)	(0.102)
GDP in PPP per capita, log (2000)	2.211***	3.984***	2.680***	4.215***
	(0.528)	(0.914)	(0.548)	(0.837)
Road transport performance (2011)	0.0391***	0.0420**	0.0359***	0.0419**
	(0.0119)	(0.0154)	(0.0121)	(0.0183)
Avg. employment growth	2.500***	1.597***	-	-
	(0.411)	(0.383)	(-)	(-)
Avg. employment growth in agriculture	-	-	-3.87e-05	-0.133*
	(-)	(-)	(6.96e-05)	(0.0681)
Avg. employment growth in mining/quarrying, manufacturing, and supply	-	-	0.259*	0.0898
	(-)	(-)	(0.155)	(0.149)
Avg. employment growth in services	-	-	1.472***	1.250***
	(-)	(-)	(0.300)	(0.207)
Spatially lagged characteristics:				
GDP in PPP per capita, log (2000)	0.177	3.207	0.576	2.603
	(1.511)	(2.393)	(1.639)	(1.925)
Employment share in agriculture (2000)	-0.199***	-0.296**	-0.177**	-0.362***
	(0.0691)	(0.113)	(0.0728)	(0.108)
Employment share in mining/quarrying, manufacturing, and supply (2000)	-0.103*	-0.235**	-0.0720	-0.290***
	(0.0605)	(0.0973)	(0.0560)	(0.0876)
Employment share in services (2000)	-0.248*	-0.649**	-0.233*	-0.686**
	(0.137)	(0.266)	(0.134)	(0.251)
Avg. employment growth	0.953	0.319	-	-
	(0.791)	(1.111)	(-)	(-)
Avg. employment growth in agriculture	-	-	0.00489*	0.249
	(-)	(-)	(0.00261)	(0.169)
Avg. employment growth in mining/quarrying, manufacturing, and supply	-	-	0.335	0.652
	(-)	(-)	(0.321)	(0.548)
Avg. employment growth in services	-	-	0.929*	0.175
	(-)	(-)	(0.561)	(0.807)
Observations	975	174	975	174
NUTS-2 region-FE	Y	Y	Y	Y

Notes: Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1
'carbon' relates to carbon-intensive EU NUTS-2 regions, as defined on in chapter 2. All specifications cover the time period 2000-2018. Initial values are taken from 2000, while dependent variable and growth variables relate to the average growth rate over the period 2000-2018. All specifications are estimated using NUTS-2 level fixed effects. Standard errors are clustered by NUTS-2 level. The spatially lagged characteristics are calculated by considering the eight nearest neighbours of each NUTS-3 region.

Figure 6 / Distribution of regression coefficients between carbon-intensive and non-carbon-intensive regions – employment growth and agricultural share

(a) Employment growth (b) Agricultural share

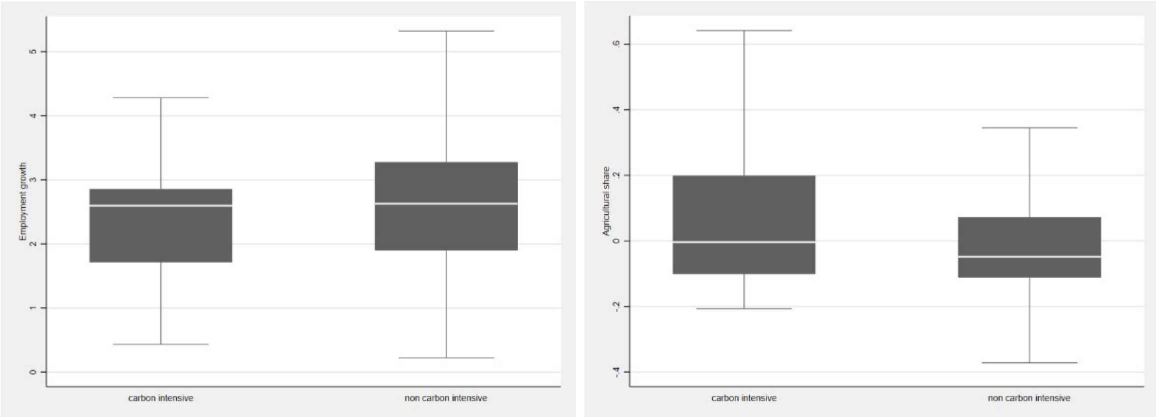


Figure 7 / Distribution of regression coefficients between carbon-intensive and non-carbon-intensive regions –industry and services share

(a) Industry share (b) Services share

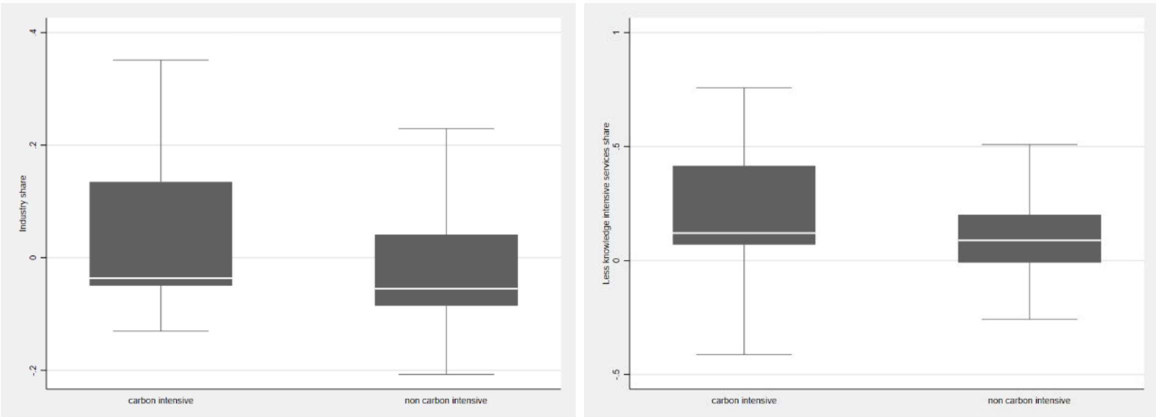
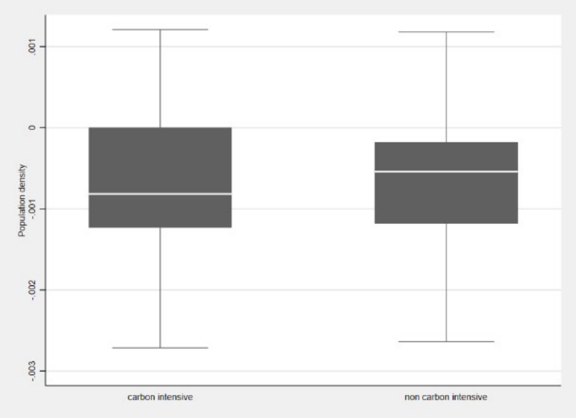


Figure 8 / Distribution of regression coefficients between carbon-intensive and non-carbon-intensive regions –population density and GDP

(a) Population density



(b) GDP

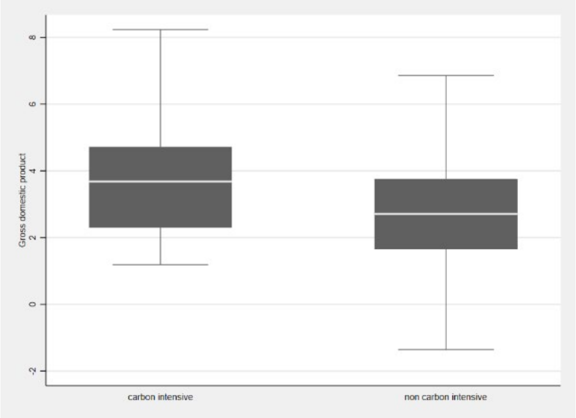
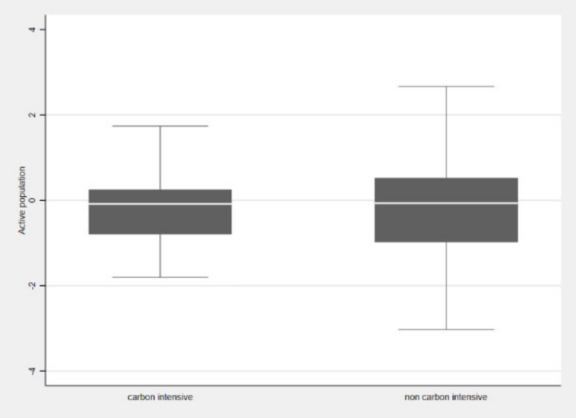


Figure 9 / Distribution of regression coefficients between carbon-intensive and non-carbon-intensive regions –active population aged 35-54 and transport performance

(a) Active population aged 35-54



(b) Transport performance

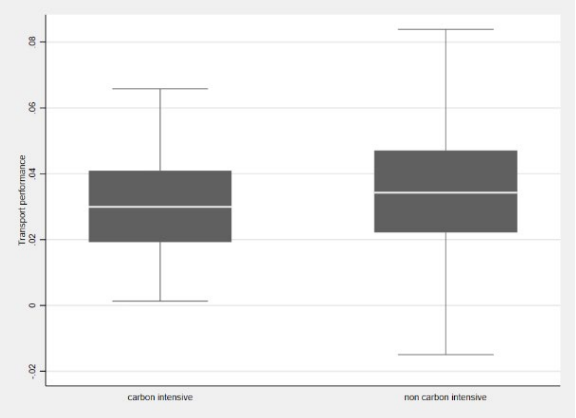
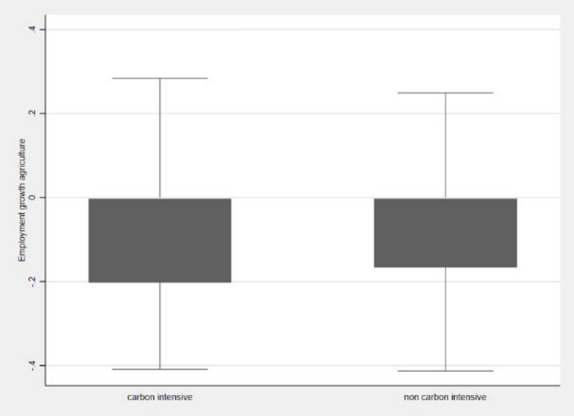


Figure 10 / Distribution of regression coefficients between carbon-intensive and non-carbon-intensive regions –employment growth in agriculture and industry

(a) Employment growth, agriculture



(b) Employment growth, industry

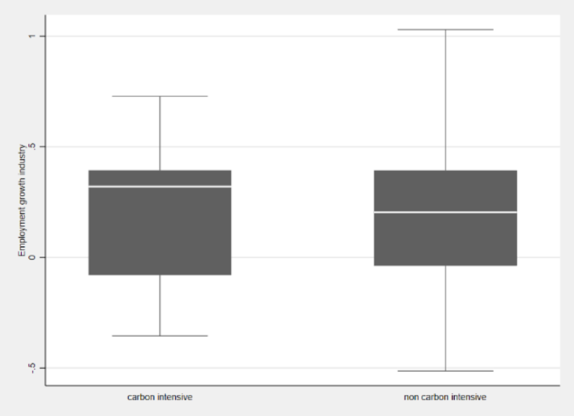


Figure 11 / Distribution of regression coefficients between carbon-intensive and non-carbon-intensive regions –employment growth in services

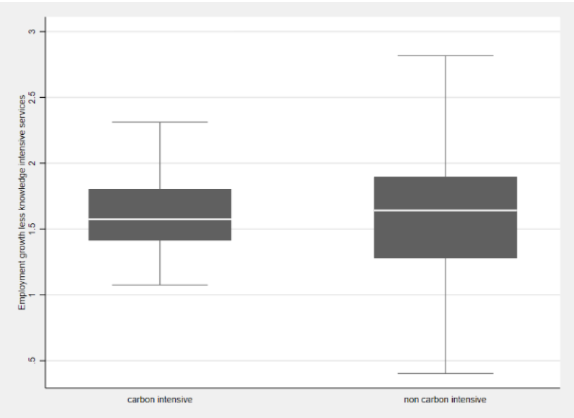
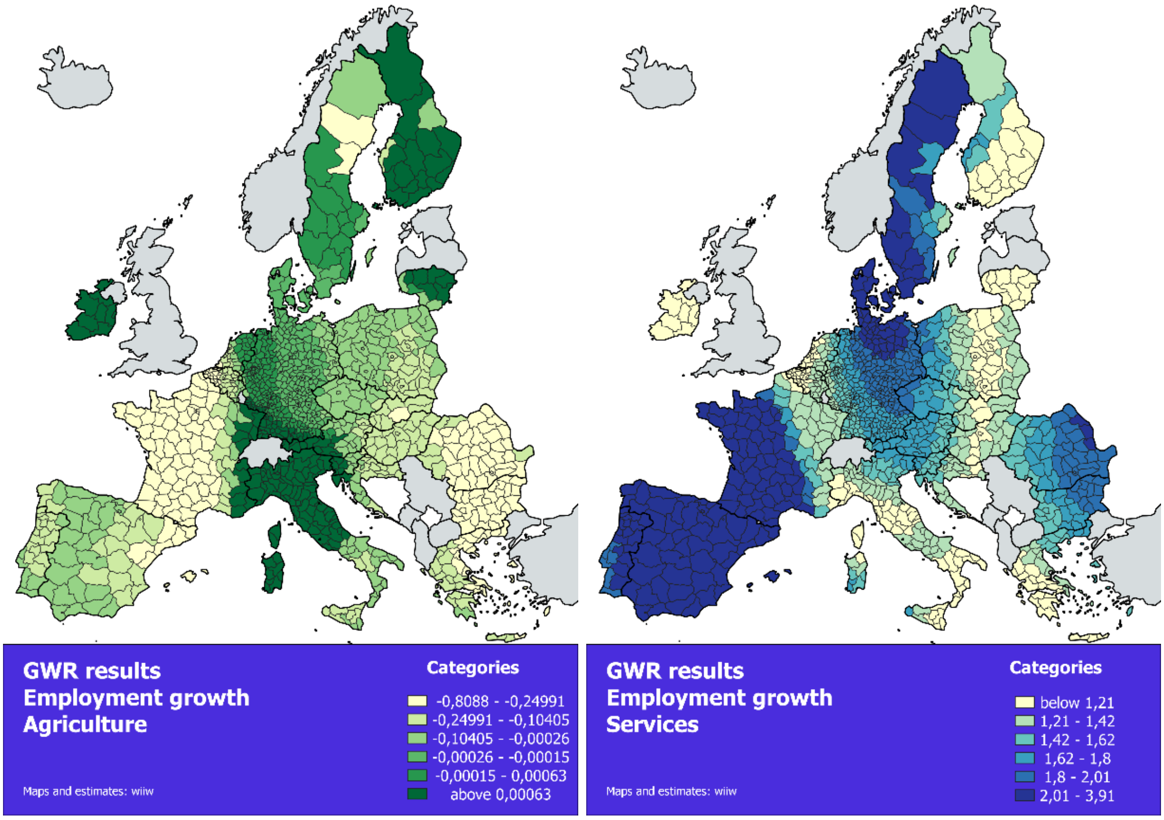
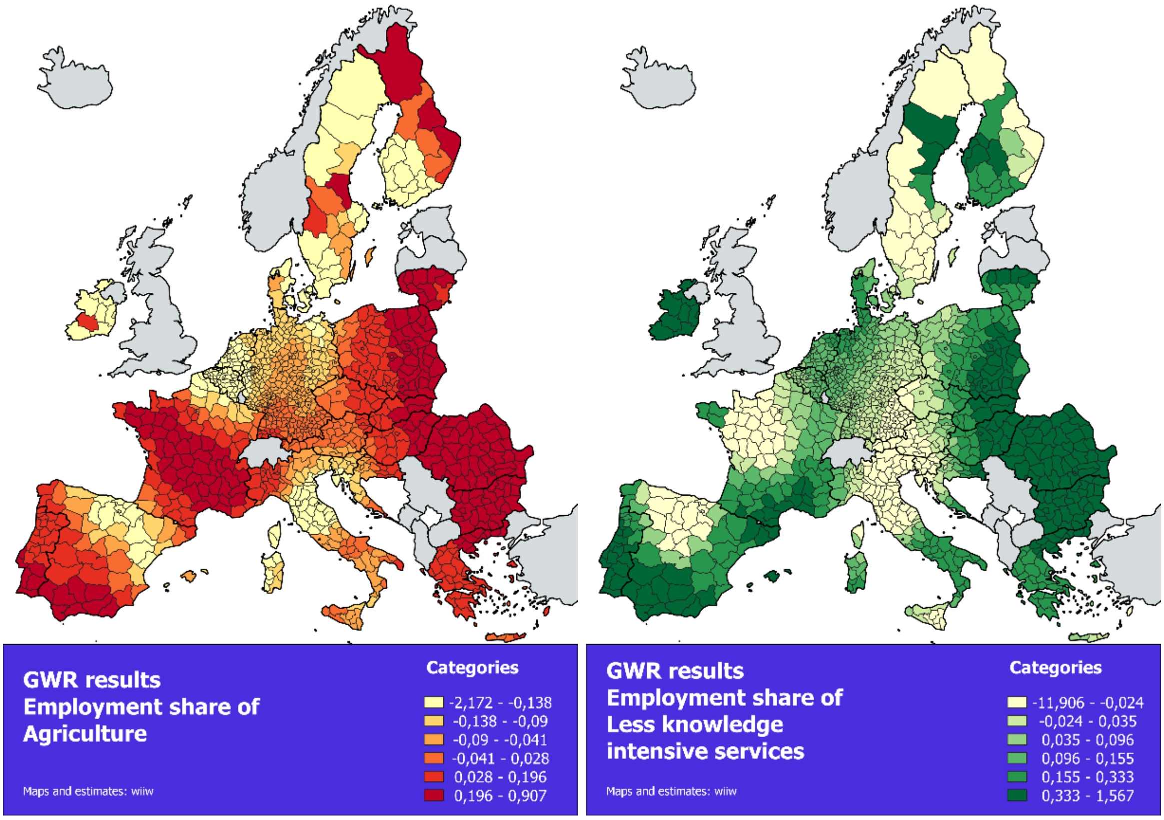


Figure 12 / Estimated territorial coefficients of the effects of employment growth in agriculture and services



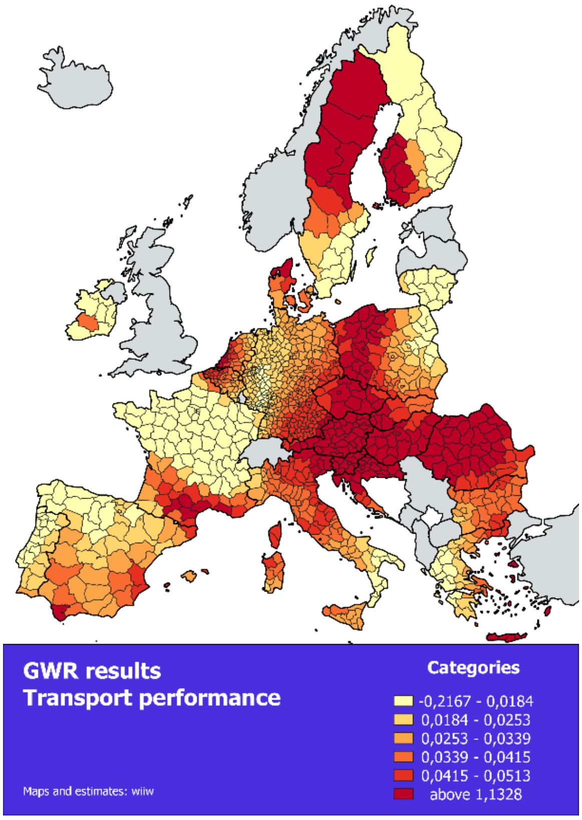
Source: wiiw maps and estimates.

Figure 13 / Estimated territorial coefficients of the effects of the specialisation in agriculture and services



Source: wiiw maps and estimates.

Figure 14 / Estimated territorial coefficients of the effects of the regions' transport performance



Source: wiiw maps and estimates.

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