FROM FOSSILS TO FOOTSTEPS:

HOW GREEN ECONOMIC TRANSITIONS SHAPE MIGRATION PATTERNS

by

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A thesis submitted in partial fulfilment of the requirements for the degree of

BA in Business Economics, Social Sciences Department

Kyiv School of Economics

2025

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ABSTRACT

This study investigates how the transition to a green economy affects internal migration patterns across European Union regions. As carbon-intensive sectors decline due to decarbonization policies, certain regions experience structural economic changes that prompt labor reallocation and demographic shifts. Using a novel panel dataset at the NUTS-3 level (2011–2021), this paper estimates a series of random-effects models to assess how carbon-intensive regions differ in migration trends compared to unaffected areas. The analysis incorporates a range of socio-demographic and economic variables to test five hypotheses on the drivers of outmigration, including youth share, elderly population, regional wealth, and median male age. Results indicate that regions classified as “affected” by the green transition exhibit significantly higher outmigration rates. Moreover, interaction effects show that aging male populations amplify these migration trends, while other moderators—such as GDP per capita and youth share—have no significant impact. These findings contribute to the literature on just transitions by highlighting how demographic composition mediates the adverse effects of green restructuring. The paper emphasizes the need for targeted regional policies, particularly in aging and economically vulnerable areas, to ensure equitable outcomes of green economic transitions.

Keywords: green transition, internal migration, carbon-intensive regions, demographic structure, panel data, just transition, NUTS-3 regions, labor mobility.

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CHAPTER 1. INTRODUCTION

The transition to a green economy—characterized by the implementation of sustainable energy systems, eco-friendly industries, and policies that prioritize environmental conservation—has profound implications for global social and economic dynamics. The environmental benefits of such transitions are enormous, including reduced pollution and enhanced resilience to climate change. Yet, there are also negative consequences arising during this transition such as the potential to reshape migration patterns, both within and across national borders.

Green transitions often lead to shifts in labor demand, which can influence migration by creating economic opportunities in some regions while displacing workers in others. The primary assumption underlying this phenomenon is that the transition fundamentally alters the demand for jobs by shifting economic focus from carbon-intensive industries to sectors aligned with sustainability and clean energy. This often results in a decline in employment opportunities in fossil fuel-based industries such as coal mining, oil extraction, and traditional manufacturing, while simultaneously creating demand in emerging fields like renewable energy, energy efficiency, electric vehicle production, and environmental restoration (Fankhauser et al.).

Additionally, this shift requires a workforce equipped with new skills, including expertise in digital technologies, green construction, and advanced manufacturing processes, emphasizing the need for reskilling and vocational training programs (OECD). However, the geographical distribution of these new opportunities may not align with the regions that lose traditional jobs, creating potential regional disparities. As a result, the green transition reshapes labor markets, creating intense outmigration from the affected regions.

This study explores the impact of the transition to the green economy on the migration patterns within the European Union, particularly focusing on the regions that heavily rely on carbon-intensive industries. By looking at the dynamics of workforce mobility, this study investigates how the closing down of traditional sectors impacts demographic shifts in the aforementioned regions. The analysis uses a nuanced approach by utilizing NUTS-3 level data to identify local variations and define socio-economic and demographic factors that may influence migration trends.

The novelty of this research lies in its integration of NUTS3 regional data with a comprehensive set of socio-economic and demographic predictors, which would address limitations in previous studies. While existing literature often focuses on aggregated data, this paper attempts to uncover the nuanced impacts on smaller regions by offering a more localized perspective. The main objective is to define how demographic characteristics influence the migration decisions of people in regions affected by the green transition. Additionally, the analysis attempts to assess, how different levels of economic development in the regions can have an impact on the intensity of outmigration, which would provide new evidence for the differentiated effects of the green transition on the communities.

There are several expected contributions resulting from this study. Firstly, it aims to improve the understanding of migration as a consequence of the green transition, by analyzing the connection between regional economic restructuring and labor mobility. Secondly, it offers policy-relevant insights by shedding light on the characteristics of individuals who are more likely to migrate and how these characteristics connect with regional economic conditions in shaping migration patterns. Finally, this work contributes to the broader discussion on just transition by emphasizing the need for honest policy frameworks that address territorial disparities while fostering sustainable development.

CHAPTER 2. LITERATURE REVIEW

The transition to a green economy represents a necessary reaction to the challenges of climate change and resource depletion. The European Green Deal reflects this idea, aiming to make Europe the first climate-neutral continent by 2050, with its implementation being expected to generate up to 2.5 million additional jobs in the EU (OECD). For instance, Popp et al. provide evidence of a significant increase in green jobs, especially increasing the need for manual workers in such sectors as waste management and construction.

However, there are also empirical studies that question this positive effect on employment. For example, Niggli and Rutzer, as reported in Vandeplas et al. (7), analyze “19 EU countries over the period 1992-2010, when environmental policy stringency (EPS)7 almost tripled and find an insignificant change in aggregate employment”. Instead, the authors reveal shifts between jobs with low and high green potential. Similarly, Mohommad, using data from up to 5300 firms across 31 countries between 2000 and 2015, concludes that tightening environmental policy stringency (EPS) has had only a modest and short-term effect on overall employment, peaking after two years and accompanied by a shift of jobs from industries and businesses with high emissions to those with low. In line with the previous findings, Vona et al. demonstrate that between 2006 and 2014 environmental policies in the United States had no significant effect on overall employment but led to an increased need for green skills.

Consistent with the above findings, many scholars emphasize that the green transition is more likely to produce some negative effects on employment, even if promoting innovation and economic recovery. Notably, the negative consequences could be linked to increased factor mobility and the redistribution of economic and social resources, which may accompany the potential concentration of green technologies within some areas (Rodríguez-Pose and Bartalucci).

Moreover, the negative consequences are expected to be particularly severe for carbon-intensive regions. “Many sectors in such regions are assumed to experience labor and skill shortages while a sizeable number of workers may need to change jobs and/or sectors”. (OECD 2). Jestl and Römisch show that “the decline of jobs in carbon-intensive industries in the affected regions, if not substituted by new jobs, decreases local employment rates, making such regions less attractive places to live and work”. (Jestl and Römisch 10). Similarly, Banerjee and Schuitema provide a case study of Ireland’s peatlands, demonstrating that a just transition can be challenging, as the closure of peat industries removes a critical source of employment, livelihood, and identity, which may cause widespread community dissatisfaction.

In addition to the negative impact on employment rates, the green transition can deepen territorial inequalities as some regions successfully shift to green economies while others are left behind. This is especially true for regions with mono-industrial bases reliant on fossil fuels (JRC) such as West Macedonia in Greece, for example. The transition away from brown energy caused an additional 3.5% employment loss there. “This put enormous pressure on a region where unemployment rates have amounted to above 30% for the last decade and where the GDP per capita level was only 75% of the Greek average” (Rodríguez-Pose and Bartalucci 342).

The decrease in the demand for workers due to the green transition can cause severe problems such as the outmigration of residents from the affected regions. According to the simulations, the impact of a carbon tax on total labor movements may be especially intense in countries with economies heavily reliant on fossil fuel industries, like those in North Africa or the Middle East, in comparison to the OECD average (Chateau, Bibas and Lanzi).

This outmigration endangers the whole idea of the green transition as it can lead to skill shortages in key sectors (OECD). The outflow of skilled workers and talent may harm innovation systems at the local and regional levels, particularly in less developed areas that already face significant challenges. A shrinking pool of qualified workers can also lower the productivity, especially that of small and medium-sized businesses (Tietjen and Jørgensen).

Additionally, outmigration can cause a decline in the quality of life and living conditions. When medium- and high-income groups leave a region, the demand for local goods and services often declines, undermining the competitiveness of the local economy. As a result, the people who stay behind frequently face unequal opportunities, largely due to the deterioration of economic and social infrastructure in both scale and quality during the transition period. (Rodríguez-Pose). A good example illustrating this negative impact has been provided by Romania's Jiu Valley, where out of 45 000 workers employed in the mines, no more than 2,000 remained employed nowadays (Kulbaczewska-Figat). Displaced coal workers have migrated to urban centers or abroad, leaving the region struggling to maintain essential public services.

The negative effects of outmigration stem from the fact that it follows a very specific pattern. First, outmigration from carbon-intensive regions is selective as those who migrate mostly represent the most significant segments of the population (OECD). Young workers are often the first to leave, being drawn by employment opportunities in urban centers and regions undergoing economic expansion. Second, outmigration can create gender and social inequalities. The male population predominantly tends to out-migrate. Women and marginalized groups may face barriers to relocation. Third, outward migration may negatively influence human capital accumulation in the affected regions as highly skilled individuals are primary candidates to abandon the place. This is because low-skilled workers experience higher costs of adaptation and an increased likelihood of losing their jobs, while these costs are substantially smaller for highly skilled people. Migrants, who are often low-skilled, are also “less likely to access training” and hence prefer to stay in the affected regions (OECD).

Yet, numerous studies recognize that the level of economic prosperity in regions predetermines the ultimate size and consequences of outmigration. Specifically, regions with lower levels of socioeconomic development face accelerated demographic decline during green transitions, as the absence of economic diversification increases vulnerabilities (McLeman). In contrast, regions with higher developmental levels, characterized by diversified economies and robust public services, demonstrate greater resilience, reducing the likelihood of outmigration (Martínez-Fernández et al.). Wealthier regions can also afford policy interventions that play a crucial role in mediating the effects of regional development on migration patterns. Development-focused strategies, such as targeted investment in education, skills retraining, and infrastructure, have been shown to mitigate outmigration by fostering new economic opportunities within transitioning regions (Strambo et al.).

Despite the extensive research conducted on the green transition effects, there are two main drawbacks remaining in this field of study that hinder the complete understanding of green transition repercussions. Firstly, many studies omit key socio-economic and demographic variables while analyzing outmigration, potentially leading to biased estimates. Secondly, research often relies on aggregated data at the NUTS-2 level, which may omit local variations and nuances.

To address these gaps, this study uses granular data from local regions (NUTS-3 level), while including a broad range of predictors in the model. Based on the literature presented above, the following hypotheses will be tested:

Hypothesis 1: Regions affected by the transition to a green economy have higher outmigration rates than regions not affected by this transition.

Hypothesis 2: The outmigration rate from the affected regions is higher if the percentage of younger people in the total population is higher.

Hypothesis 3: The outmigration rate from the affected regions is lower if the percentage of elderly population (65+) is higher.

Hypothesis 4: Affected regions with younger male population are more likely to envisage more intense outmigration.

Hypothesis 5: Outmigration from the affected regions is less intensive if such regions are more economically developed.

CHAPTER 3. DATA AND METHODS DESCRIPTION

The data for this study is sourced from Eurostat, which is an established and reliable database for socio-economic statistics across European Union (EU) member states and candidate countries. In this study, the dataset covers all EU member states, excluding EU candidates to avoid issues related to the availability and consistency of data, which would ensure a comprehensive analysis of migration patterns within the union. The covered period spans from 2011 to 2021**,** capturing long-term trends in labor mobility in response to the green economy transition.

The data are collected at the NUTS-3 regional level**,** which provides detailed insights into local dynamics. This choice increases the ability to detect regional migration trends and their socio-economic drivers as well as helps to address the limitation of usage of broader aggregate data which was identified in prior studies.

The dependent variable in this analysis is migration, which is operationalized through the net migration rate (*NetMR*), and is measured as the difference between in-migration and out-migration in each region, standardized per 1,000 inhabitants. This metric reflects the intensity of population movements and serves as a proxy for the migratory impacts of green economic transitions.

The main independent variable is a dummy variable indicating whether or not a region is carbon-intensive (*Affected)*. This binary indicator takes the value of one if the regions are heavily reliant on carbon-based industries such as coal mining and fossil fuel production and the value of zero if otherwise. The list of carbon-intensive regions has been taken from the document produced by the Just Transition Fund (JTF). Regions are classified as affected if they are marked by the JTF as eligible for funding (European Commission).

The additional independent variables are categorized into two groups. On the one hand, a set of demographic predictors has been included, such as: the rate of natural population change (*PopChange),* measured as births minus deaths per 1,000 people, percentage of the population aged 20–24 (*Pop20to24)*, percentage of individuals aged 65 and older (*Pop65+)*, median age of males (*MedAgeM)*, and population density *(PopDensity)*, measured as inhabitants per square kilometer. On the other hand, economic development predictors have been controlled for, including GDP per capita in purchasing power standards (*GDPperC)*, measured as the ratio between the level of gross domestic product expressed in purchasing power standards. Additional controls include total population (*TotalPop)* to capture the size of the region and the percentage of the added value produced by the industry (*ValAdd)*, which is supposed to capture the extent of industry development in the region. All the mentioned variables are measured using standardized definitions and methodologies provided by Eurostat.

The demographic indicators are assumed to capture population structure and its potential mobility, while economic indicators are expected to approximate how resilient or vulnerable a region is to green transition. Table 1 provides summary statistics for the selected variables (see Table 1).

Specifically, Table 1 suggests that the dataset comprises 6,613 observations across various European regions. The 'Affected' variable, the one used to measure areas covered by the green transition, holds a mean of 0.080. This means that approximately 8% of the regions in the dataset can be classified as "affected." The median age for males is 43.26 years with a relatively narrow standard deviation of 3.39 years, which reveals slight demographic variability among the sampled territories. Notably, the aged population proportion (65 years and older) on average is 20.92%, while the percentage of individuals aged 20 - 24 amounts, on average, to 5.5%, which is consistent with demographic patterns in contemporary Europe. Economic indicators such as GDP per capita and gross value-added display considerable variation since their high standard deviations point towards economic differences across the regions. Similarly, demographic variables regarding population size, rate of change and density show a substantial variation across regions, reflecting the prevalence of regional differences in the size of their territories and populations.

Table 1: Descriptive statistics for the variables used in the analysis.

Statistic	N	Mean	St. Dev.	Min	Max
NetMR	6,613	3.327	6.589	-42.100	74.600
MedAgeM	6,613	43.260	3.392	33.200	53.500
Affected	6,613	0.080	0.272	0	1
Pop20to24	6,613	5.468	1.165	2.300	11.200
Pop65+	6,613	20.918	3.423	8.600	36.700
GDPperC	6,613	27,415.29	12,958.530	6,200.000	173,800.000
ValAdd	6,613	10,143.060	17,645.010	164.090	223,677.400
PopChange	6,613	-2.210	3.481	-16.900	13.500
PopDensity	6,613	427.438	1,103.209	1.900	21,490.000
TotalPop	6,613	383,274.000	471,791.400	18,814	6,641,649

The relationship between the net migration rate and the independent variables is modeled using the following functional form:

NetMR = f(Affected, PopChange, Pop20to24, Pop65+, MedAgeM, PopDensity, GDPperC, TotalPop, ValAdd)

More specifically, the regression model can be expressed as follows:

$$NetMR = \beta 0 + \beta 1 Affected + \beta 2 PopChange + \beta 3 Pop20to24 + \beta 4 Pop65+ + \beta 5 MedAgeM + \beta 6 PopDensity + \beta 7 GDPperC + \beta 8 TotalPop + \beta 9 ValAdd + e$$

The above model allows for a detailed examination of how the socio-economic and demographic variables, along with the variable defining the involvement in the green transition, predict migration trends. The estimation of the coefficient on *Affected* will test Hypothesis 1. To examine how these socio-economic and demographic variables interact with carbon-intensive characteristics in influencing migration trends, the following model will be estimated:

$$NetMR = \beta 0 + \beta 1 Affected + \beta 2 PopChange + \beta 3 Pop20to24 + \beta 4 Pop65+ + \beta 5 MedAgeM \ \beta 6 PopDensity + \beta 7 GDPperC + \beta 8 ValAdd + \beta 9 TotalPop + \beta 10 (Affected*Pop20to24) + \beta 11 (Affected*Pop65+) + \beta 12 (Affected*MedAgeM) + \beta 13 (Affected*GDPperC) + e$$

Specifically, the *Affected*Pop20to24, Affected*Pop65, Affected*MedAgeM, and Affected*GDPperC* represent interactions between the belonging to the carbon-intensive group of regions and their key features. These interactions are intended to test hypotheses 2 to 5.

The model will be estimated by using a nested panel data approach with random effects**.** The application of nested error component modeling is necessary to control for the hierarchical structure of the data as NUTS-3 regions are clustered within countries. A panel data estimation technique is well-suited for handling longitudinal data across regions, as it accounts for both cross-region and cross-time variations. The random effects model is chosen over fixed effects because it allows for the inclusion of time-invariant variables, such as the carbon intensity dummy.

The analysis aims to decompose the total variance into components attributable to the country level, regional level, and idiosyncratic level, offering insights into the relative importance of each source of variation. Additionally, the inclusion of random effects enables consistent estimation of time-invariant variables while still maintaining robustness to hierarchical dependencies in the data.

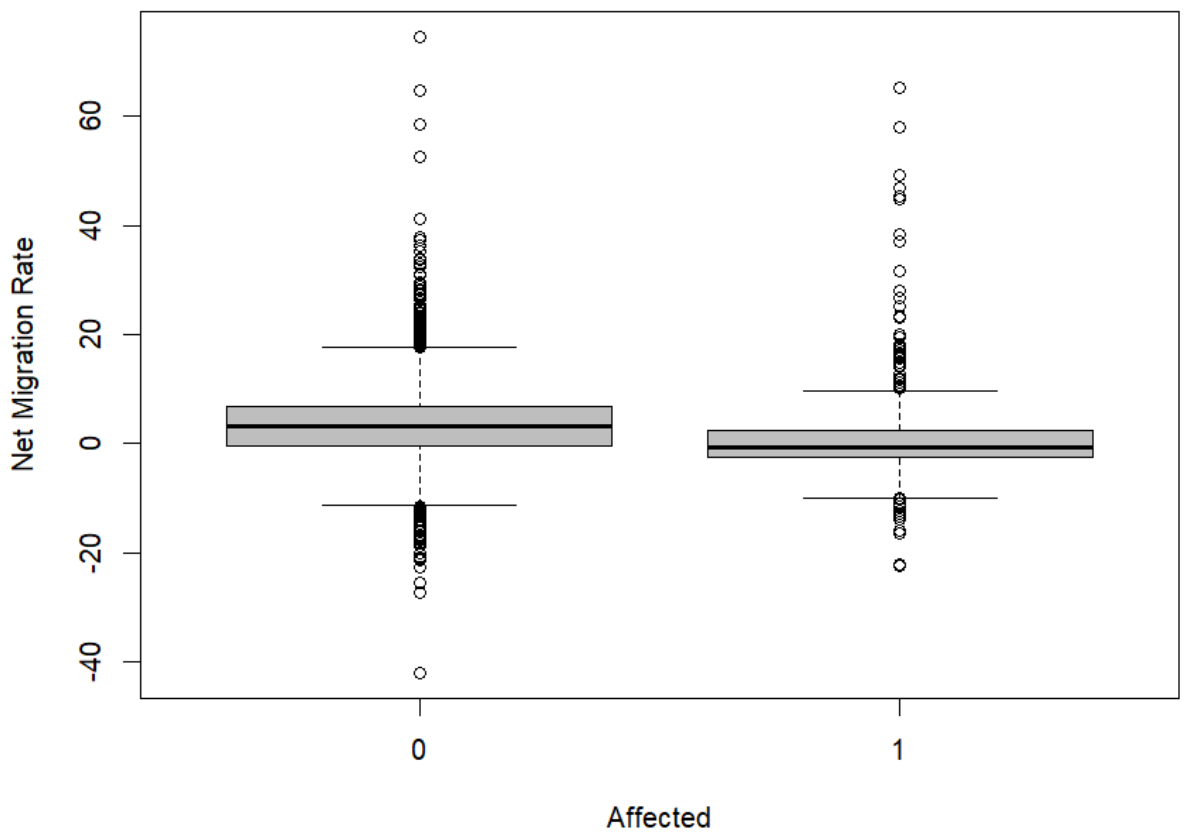
Even if the selected analytical framework can potentially provide good insights, it is not without limitations. Firstly, the reliance on NUTS-3 level data introduces challenges related to data availability and consistency across regions. Certain variables have missing values for specific years, requiring exclusion. Second, the random effects model assumes that unobserved regional characteristics are uncorrelated with the independent variables, which, if violated, could bias the results. Lastly, the use of net migration rate as the dependent variable may oversimplify complex migration dynamics, as it does not distinguish between short-term and long-term mobility or between voluntary and forced migration. Despite these limitations, the intended analysis is expected to provide insightful results regarding the impacts of green transitions on migration patterns in the EU.

CHAPTER 4. EMPIRICAL ANALYSIS AND RESULTS

We begin the analysis by inspecting the boxplot presented in Figure 1 (see Figure 1).

Comparing the median net migration rate between affected and non-affected regions reveals that the affected regions are characterized by slightly more negative net migration rates compared to non-affected regions. This indicates preliminary support for the hypothesis that regions experiencing the green transition face higher outmigration.

Figure 1. Net migration rate by the "affected' variable.



Following this, correlations were computed and summarized in Table 2 to explore the preliminary relationships among the selected variables (see Table 2). Correlation analysis indicates significant associations between net migration rates and several predictors.

In particular, the examination of the correlations with the dependent variable revealed the following insights: Net migration rates (*NetMR)* and *Affected* variable proved to have a negative correlation of -0,10. The negative correlation indicates that regions classified as "affected" by the green transition tend to have slightly lower or more negative net migration rates. Even if the effect is small, this negative association is consistent with the hypothesis that the economic restructuring in affected regions may lead to increased outmigration.

However, the weak magnitude suggests that when considered alone, the binary status of being affected does not strongly determine migration flows and other factors or interactions might influence its impact in a multivariate setting. A moderate positive correlation of 0,32 is observed between net migration rates and GDP per capita. This points out that regions with higher economic prosperity tend to experience higher net migration (or lower net outmigration). Economically stronger regions are likely to offer better employment opportunities, services, and living conditions, which attract migrants. This moderate correlation reinforces the idea that economic performance is an important driver of migration patterns, and it also provides preliminary support for the positive association that more prosperous regions generally attract or retain more population.

Also, a modest positive correlation of 0,16 between net migration rates and the rate of natural population change was observed. It indicates that regions with higher natural population growth (i.e., more births relative to deaths) tend to also exhibit higher net migration rates.

Table 2: Correlations among the variables included in the analysis.

	1	2	3	4	5	6	7	8	9	10
1. NetMR	1.000	-0.101	0.088	0.073	0.006	0.316	0.028	0.162	0.003	-0.077
2. Affected	-0.101	1.000	-0.017	-0.039	0.015	-0.106	-0.039	-0.080	-0.064	0.005
3. MedAgeM	0.088	-0.017	1.000	-0.678	0.870	-0.124	-0.289	-0.739	-0.236	-0.349
4. Pop20to24	0.073	-0.039	-0.678	1.000	-0.574	0.288	0.127	0.485	0.203	0.071
5. Pop65+	0.006	0.015	0.870	-0.574	1.000	-0.101	-0.241	-0.778	-0.187	-0.297
6. GDPperC	0.316	-0.106	-0.124	0.288	-0.101	1.000	0.430	0.359	0.411	0.117
7. ValAdd	0.028	-0.039	-0.289	0.127	-0.241	0.430	1.000	0.409	0.495	0.848
8. PopChange	0.162	-0.080	-0.739	0.485	-0.778	0.359	0.409	1.000	0.272	0.353
9. PopDensity	0.003	-0.064	-0.236	0.203	-0.187	0.411	0.495	0.272	1.000	0.277
10. TotalPop	-0.077	0.005	-0.349	0.071	-0.297	0.117	0.848	0.353	0.277	1.000

Despite this association not being very strong, it may indicate that regions experiencing demographic growth are more dynamic in attracting or retaining residents, potentially because of a combination of positive local economic conditions and social factors.

Furthermore, some correlation among independent variables has also been found for the demographic variables, the median age of males and the percentage of people over 65 display a fairly strong positive correlation (0,87). Regions with an older median age naturally have a larger share of elderly individuals. Also, the percentage of the population aged 20-24 is negatively correlated with the percentage of people over 65 and the median age of males, reflecting the inverse distribution of younger vs. older population groups within regions.

Regarding economic predictors, the following correlations were observed. GDP in PPS per capita and gross value added in euro exhibit a moderate correlation (0.43), reflecting that both measure related aspects of economic strength. Population density, total population, and the above-mentioned economic measures (GDP, GVA) also show moderate positive correlations, consistent with the fact that urbanized and populous regions often are economically more developed.

The strong correlations among demographic age-structure variables (the median age of males, the proportion of elderly, and the proportion of youth) may indicate potential multicollinearity if all are included in a single regression. The same goes for moderate correlations among economic indicators, which suggests that caution is needed to avoid unstable coefficient estimates. Nonetheless, each variable captures a distinct dimension of the region's socio-economic profile, so stepwise selection can mitigate collinearity concerns.

To explore the relationship between the green transition represented by the 'affected' variable and regional net migration rates, several random-effects panel data models were estimated, as the key independent variable is time-invariant. Table 3 summarizes the estimated coefficients for these models (see Table 3).

Table 3: A panel regression analysis of net migration rates.

	Dependent variable:				
	Net migration rates				
	(1)	(2)	(3)	(4)	(5)
Affected	-1.023**	-1.030**	-0.867**	-0.887**	-0.996**
	(0.490)	(0.491)	(0.434)	(0.435)	(0.439)
MedAgeM	1.374***	1.392***	0.591***	0.568***	0.610***
	(0.085)	(0.083)	(0.106)	(0.101)	(0.101)
Pop20to24	0.879***	0.905***	0.232	0.202	0.212
	(0.141)	(0.138)	(0.145)	(0.141)	(0.141)
Pop65+	-0.652***	-0.656***	-0.476***	-0.526***	-0.544***
	(0.081)	(0.081)	(0.092)	(0.080)	(0.080)
GDPperC	0.0001***	0.0001***	0.0001***	0.0001***	0.0001***
	(0.00001)	(0.00001)	(0.00001)	(0.00001)	(0.00001)
PopDensity	-0.001***	-0.001***	-0.001***	-0.001***	-0.001***
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
PopChange	0.375***	0.369***	0.077		
	(0.061)	(0.061)	(0.078)		
ValAdd	0.00000				

	(0.00002)				
TotalPop	-0.00000				
	(0.00000)				
Country dummies	No	No	Yes	Yes	No
Constant	-49.332***	-50.273***	-14.769***	-12.766***	-15.808***
	(3.395)	(3.200)	(4.608)	(3.950)	(3.721)
Observations	6,613	6,613	6,613	6,613	6,613
R^2	0.073	0.073	0.140	0.139	0.016
Adjusted R^2	0.072	0.072	0.135	0.134	0.015
F Statistic	531.810***	529.706***	1,083.271***	1,071.947***	103.151***

*Note: *** p<0.01, ** p<0.05, * p<0.10.*

Model 1 incorporates all available predictors and reveals statistically significant associations between migration rates and a great number of the included predictors. The model demonstrates a significant negative relationship between the 'affected' status and net migration rates (β = -1.023, p<0.05), indicating higher outmigration from regions impacted by the green transition. The main predictors such as the median age of males, the percentage of individuals aged 20-24, the percentage of older individuals (65+), and GDP per capita showed significant relationships.

However, the variables *ValAdd* and *TotPop* were statistically insignificant. The insignificance of *ValAdd* could reflect regional economic complexities not fully captured by this aggregate measure. Similarly, the insignificance of *TotPop* suggests that migration rates might not be directly dependent on the absolute size of the population, but rather on their demographic and economic characteristics.

Model 2 adjusts the predictors by omitting the insignificant predictors, yielding slightly reduced complexity without a loss of explanatory power. The coefficients and their significance remain largely consistent for the main variables under study, highlighting robustness in the primary findings concerning 'affected' regions and the retained predictors.

Model 3 introduced country-level fixed effects, accounting for potential unobserved heterogeneity at the national level. Including country dummies considerably increased the model's explanatory power (Adjusted R^2 improved from approximately 0.07 to 0.14), emphasizing significant differences in migration dynamics across countries. The estimated coefficient on the '*Affected*' predictor slightly decreased ($\beta = -0.867$, $p<0.1$). However, it remained statistically significant, underlining a robust negative impact of the green transition on net migration.

Model 4 further refines the calculations by excluding less significant indicators such as the rate of national population change. However, the predictor capturing the share of young people in the population is retained even if not statistically significant. This choice is due to the fact that this variable represents a factor of interest with regard to which hypotheses were formulated. The coefficient estimates on the key predictors remain consistent with earlier models.

Model 5 tests the robustness of Model 4 by employing nested random-effects modeling accounting explicitly for country-level clustering. This approach is more appropriate for the hierarchical data as it separates variability into idiosyncratic, individual (regional), and group (country) components. The results still demonstrate a strong negative impact of the green transition on migration rates ($\beta = -0.996$, $p<0.05$). Moreover, there is consistency in the estimated coefficients between Model 5 and Model 4 for all the predictors included in the analysis, suggesting their robustness to method selection.

Additionally, the output on variance decomposition (see Table 4) suggests that about 17,5 percent of the overall variance in net migration rates across NUTS-3 regions can be attributed to differences across countries. Specifically, the variance can be decomposed into three components: idiosyncratic, individual, and group effects. The idiosyncratic variance is the largest (18.093) with a standard deviation of 4.254, accounting for 52.4% of the total variance. This suggests that more than half of the variability is due to unobservable factors specific to each observation. The individual effect has a variance of 10.426, with a standard deviation of 3.229, making up 30.2% of the total variance, implying that a significant portion of the variation is attributable to individual-specific characteristics. Lastly, the group effect has the smallest variance (5.988) and standard deviation (2.447), contributing 17.4% of the total variance.

The theta values indicate the relative importance of the individual and group components in explaining the observed variance. The median theta for individual effects is 0.526, meaning that approximately 53% of the variation is due to individual-specific components. The group theta median is 0.404, with values ranging from 0.017 to 0.563, revealing that while group-level effects matter, they are generally less influential than individual effects. These results imply that while both individual and group effects are important, the majority of the variation is explained by idiosyncratic and individual-specific factors.

Drawing upon the above conclusions, Model 4 is selected for the interpretation and further calculations. The coefficient estimate on the affected variable in Model 4 is almost identical to that in Model 5. Additionally, this model provides better explanatory power.

Table 4. Decomposition of the variance in net migration rates.

Type	Variance	Std. dev.	Share
Idiosyncratic	18.093	4.254	0.524
Individual	10.426	3.229	0.302
Group	5.988	2.447	0.174

The coefficient for the base binary variable 'affected' is negative and statistically significant, indicating that regions classified as affected by the green transition, on average, have a net migration rate that is approximately 1 unit less than that for unaffected regions. This finding supports the hypothesis that structural changes linked with the green transition are associated with greater outmigration.

An increase of one year in the median age of males was proven to be associated with an increase of about a half unit in the rate of net migration. This positive association could reflect that regions with older male populations are more settled and have lower outmigration rates. At the same time, this may mean that such regions possess characteristics that make them more appealing to migrants.

The percentage of young people has an insignificant coefficient at standard levels. Keeping other factors constant, the ratio of those aged 20–24 does not have any independent effect on net migration. The impact of a population with young age could be mediated by other socio-economic variables.

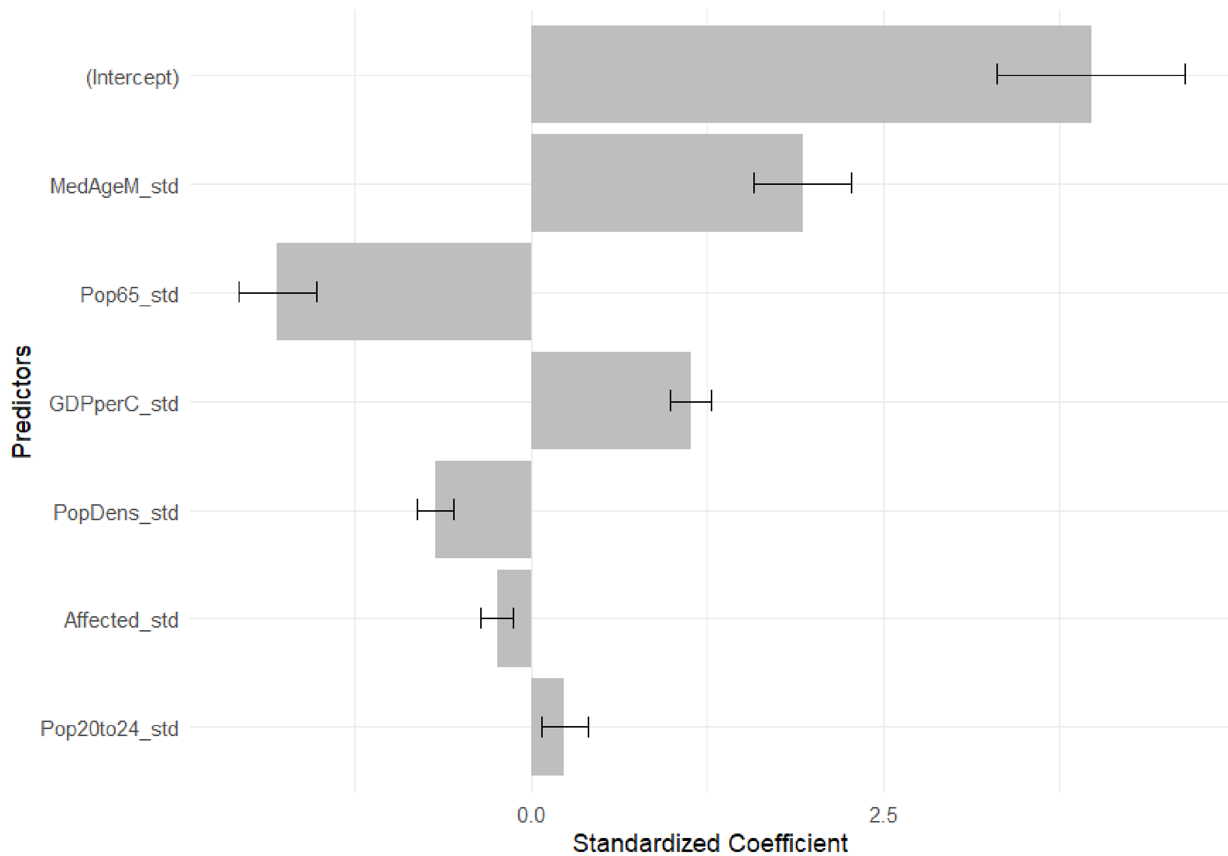
A one-percentage-point rise in the percentage of the elderly population (65+) is associated with a decrease of approximately 0.53 units in the rate of net migration. This negative relation is as one would expect, because regions that have a higher percentage of the aged population may be less able to attract immigrants or may have higher outmigration due to a weaker labor market.

The highly significant coefficient for GDP per capita shows that greater economic prosperity is associated with greater net migration. Although the coefficient number is small, the scale of GDP per capita shows that economically significant changes can have considerable effects. An increase of 10,000 in GDP per capita, for instance, would be associated with an increase of almost 1 unit in the net migration rate, suggesting the importance of local economic performance.

Lastly, population density has a strong negative effect on net migration rates, suggesting that densely populated areas experience lower net migration rates. It can be explained by the fact that increased population density reflects rising cost of living or declining quality of life in regions of very dense concentrations that discourage migrants.

To compare the impact of the selected predictors, standardized estimates have been calculated and illustrated in Figure 2 (see Figure 2). Accordingly, *GDPperC* (1.13) and *Pop65* have the strongest effects, as they have the highest absolute values and are statistically significant ($p < 0.001$). *MedAgeM* (1.93) also has a strong impact.

Figure 2. Standardized coefficients form a panel regression model (Model 4).



In contrast, *Pop20to24* (0.236) has the weakest effect, with the smallest absolute estimate and a higher p-value (0.152), indicating it is not statistically significant. Other predictors like *PopDens* (-0.683) and *Affected* have moderate effects, with *PopDens* being more influential due to its larger absolute estimate. Overall, it is possible to conclude that the transition to a green economy is not a defining factor of migration dynamics. Yet, it can have a negative influence by reducing net migration rates.

To explore the potential moderating effects that socio-economic predictors conduct on the relationship between the affected status and net migration rates, interactions between the '*Affected*' and key demographic and economic variables were tested following the formulated hypotheses. Table 5 summarizes the output for the interaction analysis, suggesting that only one interaction is statically significant (see Table 5).

Table 5. Summary of the output for the interaction analysis.

	Dependent variable:			
	Net migration rates			
	(1)	(2)	(3)	(4)
Affected	22.903***	-1.294	0.650	-1.050
	(4.548)	(1.600)	(2.321)	(1.142)
MedAgeM	0.629***	0.565***	0.567***	0.565***
	(0.102)	(0.101)	(0.101)	(0.101)
Pop20to24	0.167	0.191	0.196	0.201
	(0.141)	(0.146)	(0.142)	(0.141)
Pop65+	-0.532***	-0.524***	-0.520***	-0.525***
	(0.080)	(0.080)	(0.081)	(0.080)
GDPperC	0.0001***	0.0001***	0.0001***	0.0001***
	(0.00001)	(0.00001)	(0.00001)	(0.00001)
PopDensity	-0.001***	-0.001***	-0.001***	-0.001***

	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Country dummies	Yes	Yes	Yes	Yes
*Affected*MedAgeM*	-0.552***			
	(0.105)			
*Affected*Pop20to24*		0.077		
		(0.290)		
*Affected*Pop65+*			-0.073	
			(0.108)	
Affected**GDPperC*				0.00001
				(0.00005)
Constant	-15.115***	-12.596***	-12.817***	-12.664***
	(3.967)	(3.959)	(3.951)	(3.952)
Observations	6,613	6,613	6,613	6,613
R^2	0.143	0.139	0.139	0.139
Adjusted R^2	0.137	0.134	0.133	0.134
F Statistic	1,106.435***	1,074.503***	1,071.702***	1,073.956***

*Note: *** p<0.01, ** p<0.05, * p<0.10.*

A significant interaction has been found between *'Affected'* and median male age (β = -0.552, p<0.01) indicating that the negative impact of the green transition on migration is exacerbated in regions with an older male population and suggesting heightened vulnerability to outmigration in aging affected regions. However, no significant interaction was found between 'affected' status and the proportion of younger individuals (ages 20-24), implying this demographic segment does not significantly modify the impact of the green transition.

Similarly, the interaction between *'Affected'* status and the proportion of the elderly population was non-significant, suggesting the proportion of elderly alone does not directly moderate the impact of being affected by the green transition. Lastly, GDP per capita did not significantly interact with the '*Affected*' variable, indicating that regional wealth levels do not alter the primary relationship between the green transition and migration rates.

In summary, the empirical findings derived from the nested random-effects panel data analysis demonstrate only partial support for the proposed hypotheses formulated based on previous theoretical and empirical literature. Specifically, the findings provide strong support for Hypothesis 1. The variable representing regions affected by the green transition (*Affected*) has a statistically significant negative coefficient, indicating that regions classified as heavily reliant on carbon-intensive industries indeed experience higher outmigration rates compared to unaffected regions. This result aligns with the existing evidence that economic restructuring that comes from a decline in carbon-intensive sectors triggers significant labor displacement and regional demographic shifts (Jestl and Römisch; Rodríguez-Pose and Bartalucci).

Similarly, the results support Hypothesis 4, revealing that affected regions with younger male populations are more likely to envisage more intense outmigration as suggested by previous studies (OECD). The interaction term is statistically significant and has a negative sign. By contrast, no support for Hypotheses 2, 3, and 5 has been received, suggesting that outmigration from the affected regions is not modified by the percentage of younger or elderly populations, as well as by regional levels of economic development. This finding contradicts prior empirical results presented by McLeman and Martínez-Fernández et al. The discrepancies may arise from the imperfect measures used to capture the population structure and level of economic development in regions.

Therefore, this study provides findings that only partially correspond to the existing literature examining the socio-economic impacts of green economic transitions on migration patterns. Consistent with Jestl and Römisch and Rodríguez-Pose and Bartalucci, this analysis confirms that green transitions exert significant demographic pressures on affected regions by stimulating higher outmigration rates. This validates the broader theoretical framework that regional economic restructuring, driven by the decline of fossil-fuel industries, creates direct pressures leading to population movements. Similarly, findings support Banerjee and Schuitema's case study on Ireland's peatlands, highlighting a concrete mechanism by which the closure of traditional industries leads to demographic shifts.

The median age of the population, particularly among males, plays a crucial role in shaping the ultimate effect of the transition to a green economy on migration dynamics in the affected regions. As the median age of the male population increases, these regions often experience lower net migration rates, which is in line with the existing evidence (Bell and Charles-Edwards; Rowe et al.). Previous research has indicated that regions with aging populations face intensified population decline due to a shrinking working-age demographic, which exacerbates economic stagnation and reduces their attractiveness to potential migrants (Champion and Shuttleworth). Additionally, aging male populations in particular may contribute to labor shortages, further discouraging inward migration and reinforcing demographic imbalances (Kurek et al.). The interplay between median age and migration is thus a critical factor in understanding regional demographic shifts and requires targeted policy interventions to mitigate negative effects (Plane).

One important inconsistency with the previous literature is observed regarding the moderating effects of regions' wealth and population structure for the relationship between the green transition and outmigration (interactions). This deviation suggests potential conditional or interactive dynamics unaccounted for in simpler models. It implies that labor mobility may be contingent on other regional characteristics or economic opportunities, which has not been explored in this study.

Alternatively, the discrepancy can be explained by the use of NUTS3 data, which provides a more detailed perspective on regional migration dynamics compared to the NUTS2 level commonly employed in previous studies. NUTS3 regions represent smaller administrative units, allowing for a more detailed analysis of local demographic and economic conditions that may be masked in broader-scale studies (Rees et al.; Rowe et al.).

For instance, while NUTS-2 data might indicate that wealthier regions experience lower outmigration due to economic resilience and green job creation, a closer look at NUTS-3 units within the same region could reveal significant intra-regional disparities. Some subregions may benefit from the green transition by attracting investment and retaining populations, while others—particularly those with declining industrial bases or aging populations—may still struggle with high levels of outmigration (Haase et al.). Similarly, population structure effects on migration may manifest differently at the NUTS-3 level, where localized labor market conditions and socio-demographic profiles conduct a more immediate influence on mobility decisions (Kurek et al.).

CHAPTER 5. CONCLUSIONS

This study attempted to look at the function of the green economic transition on regional net migration patterns of European areas. Employing rich panel data at the NUTS-3 level, the analysis aimed at investigating whether regions significantly impacted by shifts away from carbon-intensive industries have higher levels of outmigration and explored the roles of demographic and economic characteristics in moderating such patterns of migration. A nested random-effects panel data model was used to control for regional and country-level heterogeneity to ensure the robustness of empirical estimates.

The empirical results support the hypothesis that regions undergoing the green transition have higher outmigration. Specifically, affected regions appear to have considerably lower net migration rates compared to the unaffected regions. In addition, the median age of the population, especially the male individuals, can worsen the situation with outmigration in the affected regions. As the age of the male population increases, the affected regions envisage lower net migration rates, likely due to more increased outmigration or lower rates of migration inflows.

The study's results have substantial theoretical implications, confirming and extending existing literature on the socio-economic impacts of structural economic transitions. Aligning with findings provided by Rodríguez-Pose and Bartalucci and Jestl and Römisch, my results reveal that economic restructuring significantly influences regional demographic shifts.

From a policy perspective, the results emphasize the critical need for tailored policy measures to mitigate the adverse socio-economic impacts of the green transition, particularly in regions reliant on carbon-intensive industries. Enhancing access to education and re-skilling programs can be crucial to equip local populations with the competencies needed for jobs in the green economy. Additionally, targeted support for regions with aging populations, such as infrastructure improvements, health services, and incentives for businesses to establish in these areas for instance, can help retain residents and attract newcomers.

Even if Ukraine was not part of this research, the obtained results can be highly relevant to the country. Ukraine's EU accession process will likely require significant commitments to a green transition, as environmental sustainability is a core priority of EU policies, particularly under the European Green Deal. Despite the challenges posed by the ongoing conflict, Ukraine has already taken steps toward aligning with EU environmental standards, including adopting its 2050 Low Carbon Development Strategy and joining the Energy Community Treaty. Key policies include the development of renewable energy infrastructure, introducing carbon pricing mechanisms, and harmonizing environmental laws with EU directives on energy efficiency, waste management, and biodiversity.

However, achieving the goals of the full green transition in Ukraine may span over significant time. Most importantly, it will require substantial investment and rebuilding efforts to reduce dependency on fossil fuels and accelerate the adoption of clean energy solutions. Given the country’s limited resources, it is unclear whether sufficient funds can be made available for the affected regions and their population to offset the negative consequences of this transition.

At the same time, this study’s findings suggest that the green transition will likely cause significant outmigration from the affected regions in Ukraine, especially if considering the country’s aging demographic profile. The government, hence, should introduce policies to *a priori* mitigate outmigration from regions heavily reliant on carbon-intensive industries. Investment in economic diversification, particularly in green and renewable energy sectors, can create new employment opportunities and foster regional resilience. Leveraging regional strengths, such as boosting GDP per capita through strategic infrastructure projects and foreign investment, will also be needed to stabilize local economies.

Despite these robust findings, the analysis has some data and methodological limitations. Specifically, the unavailability of complete data on individuals' education and skills on the NUTS-3 level restricted the scope for a more thorough analysis of migration selectivity, and the comparatively low explanatory power of the model indicates unobserved heterogeneity still influences migration flows. Future research should hence overcome these constraints by incorporating comprehensive micro-level information on education and skill compositions to provide further insights into migration selectivity processes. Additionally, examining interactions between demographic and labor market determinants with more sophisticated econometric approaches, such as instrumental variable techniques, for instance, may be of high value for an in-depth understanding. Research extending beyond the European experience, notably covering transition economies like Ukraine, would also contribute to the comparative perspective and enhance policy relevance.

WORKS CITED

Banerjee, Aparajita, and Geertje Schuitema. «Spatial Justice as a Prerequisite for a Just Transition in Rural Areas? The Case Study from the Irish Peatlands». *Environment and Planning C: Politics and Space*, vol. 41, no. 6, September 2023., pp. 1096–112. *DOI.org (Crossref)*, https://doi.org/10.1177/23996544231173210.

Bell, Martin, and Elin Charles-Edwards. *Cross-national comparisons of internal migration: An update on global patterns and trends*. Unpublished, 2013. *DOI.org (Datacite)*, https://doi.org/10.13140/RG.2.1.3489.1769.

Champion, Tony, and Ian Shuttleworth. «Are People Changing Address Less? An Analysis of Migration within England and Wales, 1971-2011, by Distance of Move: Are People Changing Address Less?» *Population, Space and Place*, vol. 23, no. 3, April 2017., p. e2026. *DOI.org (Crossref)*, https://doi.org/10.1002/psp.2026.

Chateau, J., et al. *Impacts of Green Growth Policies on Labour Markets and Wage Income Distribution: A General Equilibrium Application to Climate and Energy Policies*. OECD Environment Working Papers, 137, November 2018. *DOI.org (Crossref)*, https://doi.org/10.1787/ea3696f4-en.

European Commission. (2021). Just Transition Fund. *European Union Reports*.

European Commission. Joint Research Centre. *Case Studies towards Green Transition in EU Regions: Smart Specialisation for Transformative Innovation.* Publications Office, 2022. *DOI.org (CSL JSON)*, https://data.europa.eu/doi/10.2760/382998.

Eurostat. (n.d.). *Population and migration statistics*. European Commission. Retrieved from https://ec.europa.eu/eurostat

Fankhauser, Sam, and Frank Jotzo. «Economic Growth and Development with Low-carbon Energy». *WIREs Climate Change*, vol. 9, no. 1, Jan 2018., p. e495. *DOI.org (Crossref)*, https://doi.org/10.1002/wcc.495.

Haase, Annegret, et al. «Conceptualizing Urban Shrinkage». *Environment and Planning A: Economy and Space*, vol. 46, no. 7, July 2014., pp. 1519–34. *DOI.org (Crossref)*, https://doi.org/10.1068/a46269.

Jestl, S., & Römisch, R. (2023). Migration Drivers in Carbon-intensive Regions in the EU. *wiiw Working Papers 236*, The Vienna Institute for International Economic Studies, wiiw.

Kulbaczewska-Figat, M. (2024) «Romania's Jiu Valley: Is there life after coal? », *Balkan Insight*. https://balkaninsight.com/2024/02/19/romanias-jiu-valley-is-there-life-after-coal/

Kurek, Sławomir, et al. «Does suburbanisation contribute to the rejuvenation of a metropolitan area? Changes in the age structure of the Kraków Metropolitan Area in Poland in the light of recent suburbanisation». *Geographia Polonica*, vol. 90, no. 2, 2017., pp. 59–70. *DOI.org (Crossref)*, https://doi.org/10.7163/GPol.0085.

OECD. *Making the Green Recovery Work for Jobs, Income and Growth*. OECD Policy Responses to Coronavirus (COVID-19), October 2020. *DOI.org (Crossref)*, https://doi.org/10.1787/a505f3e7-en.

Martinez-Fernandez, Cristina, et al. *Demographic Change and Local Development: Shrinkage, Regeneration and Social Dynamics*. OECD, 2012. *DOI.org (Crossref)*, https://doi.org/10.1787/9789264180468-en.

McLeman, Robert A. *Climate and human migration: past experiences, future challenges*. Cambridge University Press, 2014.

Mohommad, Adil. «Employment Effects of Environmental Policies – Evidence From Firm-Level Data». *IMF Working Papers*, vol. 2021, no. 140, May 2021., *DOI.org (Crossref)*, https://doi.org/10.5089/9781513573618.001.

OECD. *Job Creation and Local Economic Development 2023: Bridging the Great Green Divide*. OECD, 2023. *DOI.org (Crossref)*, https://doi.org/10.1787/21db61c1-en.

OECD. *Promoting Growth in All Regions*. OECD, 2012. *DOI.org (Crossref)*, https://doi.org/10.1787/9789264174634-en.

Plane, D. A., et al. «Migration up and down the Urban Hierarchy and across the Life Course». *Proceedings of the National Academy of Sciences*, vol. 102, no. 43, 2005., pp. 15313–18. *DOI.org (Crossref)*, https://doi.org/10.1073/pnas.0507312102.

Popp, David, et al. «Green Stimulus in a Post-Pandemic Recovery: The Role of Skills for a Resilient Recovery». *Environmental and Resource Economics*, vol. 76, no. 4, August 2020., pp. 901–11. *DOI.org (Crossref)*, https://doi.org/10.1007/s10640-020-00464-7.

Rees, Philip, et al. «European Regional Populations: Current Trends, Future Pathways, and Policy Options». *European Journal of Population / Revue Européenne de Démographie*, vol. 28, no. 4, November 2012., pp. 385–416. *DOI.org (Crossref)*, https://doi.org/10.1007/s10680-012-9268-z.

Rodríguez-Pose, Andrés, and Federico Bartalucci. «The Green Transition and Its Potential Territorial Discontents». *Cambridge Journal of Regions, Economy and Society*, vol. 17, no. 2, 2023., pp. 339–58. *DOI.org (Crossref)*, https://doi.org/10.1093/cjres/rsad039.

Rodríguez-Pose, Andrés. «The Revenge of the Places That Don't Matter (and What to Do about It)». *Cambridge Journal of Regions, Economy and Society*, vol. 11, no. 1, March 2018., pp. 189–209. *DOI.org (Crossref)*, https://doi.org/10.1093/cjres/rsx024.

Rowe, Francisco, et al. *Impact of internal migration on population redistribution in Europe: Urbanisation, counterurbanisation or spatial equilibrium?* 2019. *DOI.org (Datacite)*, https://doi.org/10.48550/ARXIV.1911.03795.

Rutzer, Christian, and Matthias Niggli. *Environmental Policy and Heterogeneous Labor Market Effects: Evidence from Europe*. WWZ Working Paper, 2020. *DOI.org (Datacite)*, https://doi.org/10.5451/UNIBAS-EP77038.

Strambo, Claudia., et al (2019). Navigating coal mining closure and societal change: learning from past cases of mining decline. *SEI Working Paper. Stockholm Environment Institute*, Stockholm.

Tietjen, Anne, and Gertrud Jørgensen. «Translating a Wicked Problem: A Strategic Planning Approach to Rural Shrinkage in Denmark». *Landscape and Urban Planning*, vol. 154, October 2016., pp. 29–43. *DOI.org (Crossref)*, https://doi.org/10.1016/j.landurbplan.2016.01.009.

Vandeplas, Anneleen., et al. Directorate General for Economic and Financial Affairs. *The Possible Implications of the Green Transition for the EU Labour Market.* Publications Office, 2022. *DOI.org (CSL JSON)*, https://data.europa.eu/doi/10.2765/583043.

Vona, Francesco, et al. «Environmental Regulation and Green Skills: An Empirical Exploration». *Journal of the Association of Environmental and Resource Economists*, vol. 5, no. 4, October 2018., pp. 713–53. *DOI.org (Crossref)*, https://doi.org/10.1086/698859.

World Bank. (2021). *World development indicators*. Retrieved from https://data.worldbank.org/