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BLAGA MADZHUROVA

Department of Economic Science, University of Plovdiv Paisii Hilendarski, Bulgaria

DOBRINKA STOYANOVA

Department of Economic Science, University of Plovdiv Paisii Hilendarski, Bulgaria

STEFAN RAYCHEV

Department of Economic Science, University of Plovdiv Paisii Hilendarski, Bulgaria

THE IMPACT OF PM2.5 EXPOSURE ON LONG-TERM UNEMPLOYMENT AND EMPLOYMENT RATES: AN ANALYSIS OF ENVIRONMENTAL AND LABOR MARKET CHALLENGES IN BULGARIA AND EUROPEAN UNION

Abstract:

This study investigates the relationship between environmental health impacts, particularly premature deaths due to fine particulate matter (PM2.5) exposure, and labour market outcomes across European Union (EU) member states from 2012 to 2021, with a special focus on Bulgaria. Utilizing a mixed-method approach that combines graphical analysis and PanelOLS regression modelling, the research examines how air pollution influences long-term unemployment and employment rates within the EU. The findings reveal a statistically significant negative correlation between PM2.5-related premature deaths and employment rates, suggesting that poor air quality contributes to lower labour market performance. Bulgaria exhibits a notable intersection of high long-term unemployment and environmental health challenges, highlighting the compounded effects of economic and environmental factors on labour market outcomes. This study underscores the importance of integrating environmental considerations into economic and labour market policies, especially for countries like Bulgaria that face significant challenges in both areas. By addressing these dual challenges, Bulgaria and other EU member states can enhance public health, improve labour market outcomes, and support a more sustainable and resilient economic future. The research contributes to the discourse on sustainable development, emphasizing the need for policies that simultaneously promote environmental health and economic productivity within the European Union.

Keywords:

Green transition, Labour market, Unemployment, Growth, Environmental health, PM2.5 Exposure, Air Pollution, Long-term Unemployment

JEL Classification: Q53, J64, I15

1 Introduction

The relationship between environmental factors and economic outcomes has garnered increasing attention in recent years, particularly in the context of sustainable development. Among the myriads of environmental challenges, air pollution remains a critical concern, with fine particulate matter (PM_{2.5}) being one of the most detrimental pollutants to public health. PM_{2.5}, due to its small size, can penetrate deep into the respiratory system, leading to severe health problems such as cardiovascular and respiratory diseases, and in many cases, premature death. The implications of these health issues extend beyond the healthcare sector, influencing broader economic outcomes, including labor market performance.

Within the European Union (EU), the economic and social impacts of air pollution are particularly pertinent given the region's diverse industrial base and varying levels of environmental regulation and economic development across member states. The interplay between long-term unemployment and environmental health challenges, such as premature deaths due to PM_{2.5} exposure, represents a significant, yet underexplored, area of study. Understanding this relationship is crucial for formulating policies that promote both economic resilience and environmental sustainability.

This study aims to investigate the correlation between premature deaths caused by PM_{2.5} exposure and labor market outcomes, particularly focusing on long-term unemployment and employment rates across EU member states over the period from 2012 to 2021.

The study is motivated by the need to address the dual challenges of improving public health and enhancing economic productivity in a sustainable manner. As the EU continues to push for a green transition, understanding the economic impacts of environmental degradation is essential for developing policies that not only reduce pollution but also support labor market recovery and growth. Through this research, we aim to contribute to the ongoing discourse on sustainable development by highlighting the importance of integrating environmental and economic policy objectives in the pursuit of long-term prosperity within the EU.

2 Literature review

Air pollution represents the greatest environmental health risk, with data from the World Health Organization indicating that around 3 million people lose their lives each year due to polluted air (WHO, 2016). Numerous medical and economic studies have established a causal link between pollution and various diseases (Graff Zivin and Neidell, 2013; Guarnieri and Balmes, 2014; Zhang et al., 2017), including respiratory diseases, subsequent hospitalizations, and mortality (Moretti and Neidell, 2011; Schlenker and Walker, 2015; Arceo et al., 2016; Anderson, 2019; Deryugina et al., 2019). There is significant economic and statistical evidence that the relationship between fine particulate matter (PM_{2.5}) pollution and daily labor activity is substantial, negative, and nonlinear. Studies using various air quality thresholds have found that the marginal effect of pollution is stronger at higher levels of contamination. Results show that on days with exceptionally high PM_{2.5} levels, the likelihood of a person working decreases by more than 5 percentage points, leading to an average reduction in hours worked on the same day by 7.5% (Hoffmann, Rud, 2022).

This raises the question of whether workers can avoid the adverse effects of high pollution levels. In such situations, they often face a dilemma between their health and their income, as performing usual job duties may increase their exposure to pollutants. This dilemma is particularly acute for low-income workers and those in the informal sector, whose income directly depends on the number of hours worked per day.

The transition to climate neutrality cannot be achieved solely through environmental policies. Cohesion policy, which constitutes about one-third of the European Union's budget, plays a key role in this process by providing funding for climate actions, investments in sustainability, and implementing specific measures in EU regions. The Just Transition Fund was created and its primary goal is to support specific territories, as identified by the European Commission and member states, as being most affected by the transition to climate neutrality. These regions, often former industrial zones or areas still dependent on fossil fuels, can rely on support for economic diversification and social measures, such as reskilling workers, job search assistance, investments in small and medium-sized enterprises, new business creation, research and innovation, environmental rehabilitation, clean energy, and enterprise transformation to address environmental challenges, including air pollution from fine particulate matter (PM_{2.5}) (Guarnieri and Balmes, 2014; Deryugina et al., 2019), which are among the most harmful pollutants for public health.

High pollution has heterogeneous effects on labor supply. Informal workers, who are often less protected and not on formal employment contracts, significantly reduce their labor supply on days with high pollution compared to formal workers. As a result, the total number of hours worked by informal workers decreases significantly more than that of formal workers during weeks with high PM_{2.5} pollution levels (Hoffmann, Rud, 2022).

Although the field of environmental justice has several conceptual and methodological weaknesses, research shows that (sub)populations and/or minorities with low socioeconomic status are disproportionately affected by environmental risks and hazards (Branis, Linhartova, 2012). Environmental (in)justice often manifests through uneven exposure to pollution and inadequate environmental protection for socially and economically vulnerable groups, while a connection has also been established between poor health, low socioeconomic status, and a deteriorated environment (Branis, Linhartova, 2012). This poses a risk to Bulgaria, and insufficient engagement in adopting the Just Transition Fund as a tool for social cohesion will jeopardize health and economic security, as reflected in the labor market.

However, it should be noted that as of January 2023, Bulgaria remains the only country that has not yet officially submitted its Territorial Just Transition Plans (TJTTPs) to the European Commission. Drafts of the TJTTPs, which focus on the three coal regions in the country—Stara Zagora, Pernik, and Kyustendil—were sent for comments to the European Commission in the autumn of 2022. However, as they were not approved, Bulgaria lost its Just Transition funding for 2022 (CEE, 2023).

3 Methodology

This study employs a mixed-method approach to analyse the relationship between long-term unemployment, environmental health impacts (specifically premature deaths due to PM_{2.5} exposure), and labour market outcomes across European Union (EU) member states from 2012 to

2021. The methodology integrates both graphical analysis and econometric modelling to provide a comprehensive understanding of these dynamics.

Data Collection: The data utilized in this analysis were sourced from Eurostat, focusing on key indicators such as unemployment rates, long-term unemployment rates, employment rates, and premature deaths attributable to PM2.5 exposure. The dataset covers 28 EU member states over a period of 10 years, providing a robust temporal and cross-sectional basis for analysis.

Graphical Analysis: The study begins with a visual exploration of labour market dynamics across the EU. Multiple graphs were constructed to depict the relationships between unemployment, long-term unemployment, and employment rates. These graphs were divided into quadrants to compare the positioning of EU member states relative to the EU27 average, allowing for the identification of outliers and trends over time.

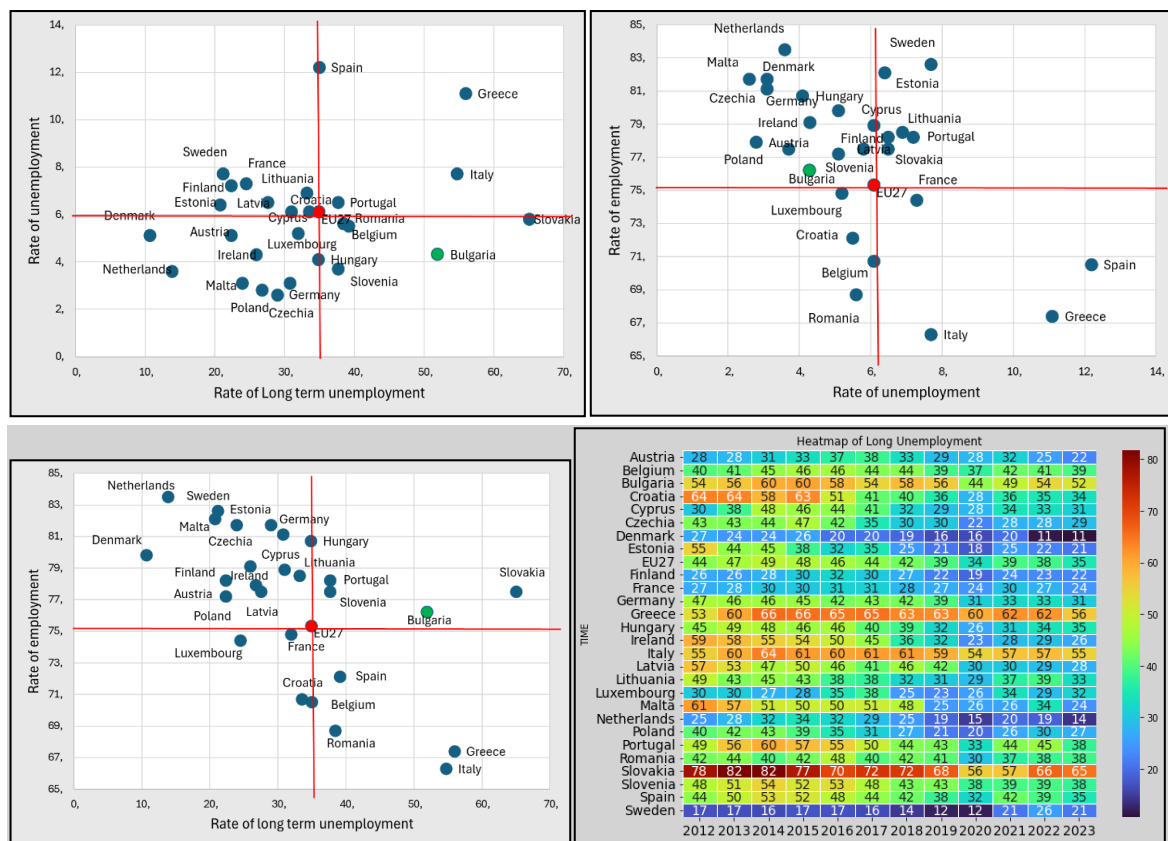
Additionally, a heatmap was used to visualize changes in long-term unemployment rates across EU member states over the 2012-2023 period. This graphical tool facilitated the identification of temporal patterns and cross-country differences in long-term unemployment, highlighting areas where persistent unemployment challenges are most severe.

Econometric Analysis: To quantitatively assess the relationship between environmental health impacts and labour market outcomes, the study employs a PanelOLS regression model. This model was chosen for its ability to handle panel data, capturing both the within-country (time-series) and between-country (cross-sectional) variations in the dataset.

The dependent variable in the regression model is the employment rate (Eu_rate), while the key independent variable is the premature death rate due to PM2.5 exposure ($Deaths_rate$). The model also includes fixed effects to account for unobserved heterogeneity across countries.

4 Research Procedure and Results

Figure 1 presents the labour market in Bulgaria and the rest of the EU member states in the period 2012-2023. Three graphs present the dependencies between the unemployment rate, long-term unemployment and employment in 2023. The graphs are divided into four segments according to the position of the EU28 and the rest EU member states. The fourth graph presents a heatmap of changes in long-term unemployment in time order by EU member state in the period 2012-2023.

Figure 1 Dynamics of the labor market in the EU for the period 2012 - 2023.

Source: Eurostat.

The upper left graph presents the relationship between unemployment and long-term unemployment rates as a crucial metric in evaluating the labour market conditions within the European Union (EU). In contrast to the EU27 average, which is the center of the graph, Bulgaria's placement in the lower right quadrant signals a significant divergence between its unemployment and long-term unemployment rates. While countries like Spain and Greece are positioned in the upper right quadrant, indicating both high unemployment and high long-term unemployment, Bulgaria's situation is distinct. The low unemployment rate suggests an economy that is generally capable of generating jobs, but the relatively high long-term unemployment rate points to structural issues that prevent certain segments of the population from re-entering the workforce once they become unemployed. The contrast of a low unemployment rate with a high long-term unemployment rate in Bulgaria are based on difficulties like mismatches in skills, regional disparities in job opportunities, and insufficient active labour market policies that effectively target long-term unemployed individuals. The persistence of long-term unemployment despite a low overall unemployment rate are a major threat about the inclusiveness of Bulgaria's labour market and the potential for entrenched social inequalities.

The interplay between employment and unemployment rates is crucial for understanding labor market efficiency within the European Union (EU). This analysis examines the second graph, which plots these rates for EU member states, with a specific focus on Bulgaria's position relative to the

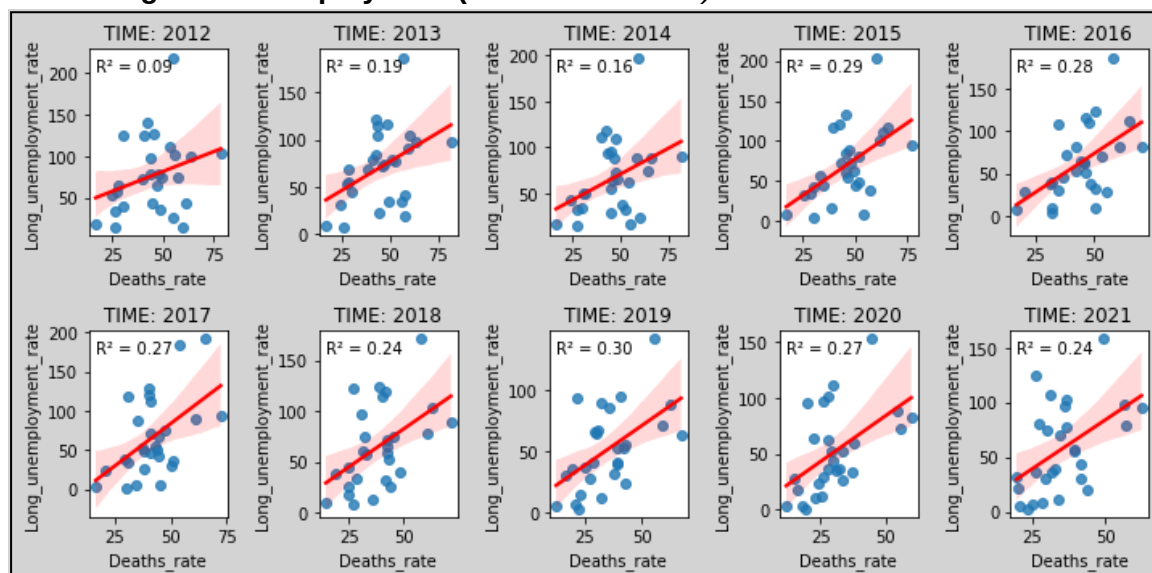
EU27 average. Bulgaria's position in the upper right quadrant, indicating high employment and low unemployment, places it alongside countries like Poland and the Netherlands, which also exhibit strong labour market performance. In contrast, countries like Spain and Greece, located in the lower right quadrant, experience high unemployment despite lower employment rates. This comparison highlights Bulgaria's relative success in maintaining a balanced labour market, where a large proportion of the population is employed, and unemployment is kept in check, unlike the more pronounced labour market challenges faced by some Southern European countries.

The third graph in the upper left of the provided data visualizations explores the relationship between the employment rate and the long-term unemployment rate among EU member states. Bulgaria is positioned in the lower right quadrant of the graph, indicating a lower employment rate combined with a higher long-term unemployment rate compared to other EU countries. This suggests challenges in Bulgaria's labour market, such as structural mismatches and insufficient job creation, which contribute to prolonged unemployment periods. In contrast, countries like Germany and the Netherlands, in the upper left quadrant, display healthier labour markets with high employment and low long-term unemployment, highlighting a stark difference in labour market efficiency and resilience across the EU.

The heatmap reveals that Bulgaria has faced persistently high levels of long-term unemployment over the past decade, though there has been some gradual improvement. While Bulgaria's situation has improved, it remains above the EU27 average and significantly higher than in the best-performing countries like Sweden and the Netherlands. Addressing the structural issues contributing to long-term unemployment will be critical for Bulgaria to further improve its labour market outcomes and align more closely with the lower levels seen in other parts of the EU.

Figure 2 presents a visualization of a regression analysis of the death rate and the long-term unemployment rate between EU countries by year in the period 2012 - 2021.

Figure 2 Linear regression analysis by year for EU member states against the equivalent of death and long-term unemployment (Source: Eurostat)



The analysis of the scatter plots reveals a growing correlation between long-term unemployment and premature deaths due to exposure to fine particulate matter (PM2.5) across European Union (EU) countries from 2012 to 2021. This correlation suggests that higher rates of long-term unemployment are associated with increased premature mortality due to poor air quality. The connection between these two factors highlights significant economic and environmental challenges faced by certain EU member states. This slow green transition exacerbates air pollution levels, leading to higher PM2.5 concentrations, which in turn contributes to adverse health outcomes such as respiratory and cardiovascular diseases.

The exposure to high levels of PM2.5 not only affects general public health but also has a direct impact on the workforce. Chronic health conditions resulting from poor air quality, such as asthma, chronic obstructive pulmonary disease (COPD), and heart disease, can reduce the ability of individuals to work, leading to lower productivity and, in many cases, long-term unemployment. In countries where air pollution is a significant issue, the workforce is more vulnerable to these health impacts, which can create a vicious cycle where poor health leads to job loss, and prolonged unemployment further deteriorates health.

Figure 3 PanelOLS regression results

PanelOLS Estimation Summary						
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Dep. Variable:	Eu_rate	R-squared:	0.2046			
Estimator:	PanelOLS	R-squared (Between):	0.1397			
No. Observations:	280	R-squared (Within):	0.2046			
Date:	Wed, Aug 14 2024	R-squared (Overall):	0.1545			
Time:	10:41:52	Log-likelihood	-675.52			
Cov. Estimator:	Unadjusted	F-statistic:	64.571			
Entities:	28	P-value	0.0000			
Avg Obs:	10.0000	Distribution:	F(1,251)			
Min Obs:	10.0000	F-statistic (robust):	64.571			
Max Obs:	10.0000	P-value	0.0000			
Time periods:	10	Distribution:	F(1,251)			
Avg Obs:	28.000					
Min Obs:	28.000					
Max Obs:	28.000					
Parameter Estimates						
=====						
	Parameter	Std. Err.	T-stat	P-value	Lower CI	Upper CI

const	78.201	0.9058	86.339	0.0000	76.418	79.985
Deaths_rate	-0.1123	0.0140	-8.0356	0.0000	-0.1399	-0.0848
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Source: Own calculations.

The PanelOLS regression analysis examines the relationship between premature deaths due to PM2.5 exposure and employment rates (Eu_rate) across EU member states from 2012 to 2021. The results show a statistically significant negative correlation between these variables, with the death rate coefficient indicating that higher mortality due to air pollution is associated with lower employment rates. Specifically, for each unit increase in the death rate, the employment rate decreases by 0.1123 percentage points.

The model explains 20.46% of the variation in employment rates within countries over time, and 13.97% of the variation between countries, highlighting that both within-country and between-country differences are relevant. The significant F-statistic and poolability test confirm the robustness of the model.

The negative and statistically significant relationship between PM2.5-related premature deaths and employment rates highlights the detrimental impact of environmental health issues on labor market outcomes. Countries experiencing higher mortality rates due to air pollution tend to have lower employment rates, suggesting that poor air quality may contribute to a less productive workforce, potentially due to health-related work absences or a reduced labor force participation rate.

The moderate R-squared values, particularly within entities, imply that while air pollution plays a role, other factors also significantly influence employment rates. These include economic conditions, labor market policies, and broader health care systems that may mitigate or exacerbate the impact of environmental factors on employment.

5 Conclusion

The PanelOLS estimation reveals a clear negative impact of PM2.5-related premature deaths on employment rates in EU member states between 2012 and 2021. This relationship underscores the importance of integrating environmental health considerations into labor market and economic policies. Reducing air pollution and improving public health could not only save lives but also enhance economic productivity and employment outcomes across the European Union. These findings suggest that addressing environmental challenges should be a priority for ensuring sustainable economic growth and improving labor market resilience within the EU.

These findings underscore the impact of environmental health issues on labor markets, suggesting that poor air quality can lead to a less productive workforce and reduced labor force participation. The analysis emphasizes the need for integrated policies that address both environmental and economic challenges, as improving air quality could enhance public health and, in turn, boost employment rates across the EU.

Supporting a green transition that is inclusive of all EU member states is crucial for reducing the economic and health disparities currently observed. This includes financial and technical support from the EU for countries struggling with these transitions, ensuring that no country is left behind in the move towards a sustainable and resilient future.

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