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Research article

Minimum wage and unemployment dynamics in the EU: A panel data analysis

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Abstract: This study investigated the impact of minimum wage policies on unemployment across 21 European Union (EU) member states from 2000 to 2023. Using panel data econometrics with fixed effects and dynamic GMM estimators, we analyzed the relationship between lagged minimum wage levels and labor market outcomes, including total unemployment, employment rates, and youth/low-skilled unemployment. Our findings revealed a statistically significant but economically modest positive effect of minimum wage increases on unemployment, consistent with neoclassical theory. Higher minimum wages were also associated with reduced employment rates and higher unemployment among youth and low-skilled workers. Robustness checks confirmed these results, addressing endogeneity and persistence in unemployment dynamics. The study highlights a policy trade-off: While minimum wage hikes may marginally increase unemployment, their social benefits (e.g., poverty reduction) could justify such measures. Policymakers in the EU must weigh these modest labor market distortions against broader equity goals.

Keywords: minimum wage; unemployment; labor markets; panel data; European Union

JEL Codes: J38, J64, J21, C23

1. Introduction

The relationship between minimum wage policies and unemployment remains a central debate in labor economics. While proponents emphasize the role of minimum wage in reducing poverty, enhancing social welfare, and stimulating aggregate demand, critics—particularly those grounded in neoclassical economic theory—highlight potential disemployment effects, especially among vulnerable groups in the labor market. Understanding the empirical link between minimum wage levels and unemployment is essential for policymakers aiming to balance social equity with labor market efficiency.

This study contributes to this ongoing discussion by empirically investigating the impact of minimum wage levels on unemployment rates across 21 European Union (EU) member states spanning the period from 2000 to 2023. We employ panel data econometrics, utilizing a baseline model with fixed cross-sectional and period effects to account for macroeconomic dynamics, institutional heterogeneity, and common temporal shocks. To rigorously assess the robustness of our findings, we extend the analysis to examine the effects of minimum wages on alternative labor market outcomes, specifically the employment rate and the unemployment rate among youth and individuals with low levels of education. Furthermore, we implement the system generalized method of moments (GMM) estimator, a dynamic panel data technique, to address potential issues of endogeneity and the inherent persistence observed in unemployment dynamics.

The results reveal a statistically significant and positive relationship between the lagged minimum wage and the current unemployment rate, a finding that aligns with certain predictions from neoclassical theory. However, the estimated magnitude of this effect suggests an economically modest impact within our sample. These results offer pertinent policy implications for the EU. Policymakers should be mindful that increases in the minimum wage may lead to adverse, albeit limited, effects on labor markets. Consequently, the decision to raise the minimum wage may hinge on a trade-off, where the pursuit of other objectives, such as poverty reduction or income equality, is deemed more significant despite the small potential increase in unemployment.

The remainder of this paper is structured as follows: Section 2 provides a literature review. Section 3 details the empirical strategy and the data employed in our analysis. Section 4 presents the main estimation results. Section 5 examines the robustness of our findings through a series of validation tests. Section 6 offers additional analysis. Finally, Section 7 concludes with a discussion of the policy implications arising from our research.

2. Literature review

Conventional economic theory suggests that imposing a minimum wage above the equilibrium level reduces employment and increases unemployment by pricing low-productivity workers out of the market (Stigler, 1946). This theoretical prediction rests on the hypothesis of competitive labor markets (marginalist view) that was challenged initially by institutional economists like Lester (1946, 1947), on the grounds that does not represent actual business practices.

Early empirical research (Goldfard, 1974) seems to support that increases in the minimum wages have adverse effects on employment, especially of low-skilled workers. Brown et al. (1982, 1983) also found that an increase in minimum wage reduce teenagers and young adults employment.

However, a series of seminal papers in the early nineties seriously challenged the above consensus, exploiting state-level variation in minimum wages and applying difference-in-differences style estimators. These studies suggested that there is no adverse effect of the minimum wage on employment (Card, 1992a; Katz and Murphy, 1992) and even a positive effect exists (Card, 1992b; Katz and Krueger, 1992). Card and Krueger's (1994) highly influential paper also implied that an increase in minimum wage raised employment, whereas Card and Krueger's (1995) book summarizes this strand of research that cast doubts on the negative effects of minimum wages on employment. Manning (2003) provided theoretical justification of the empirical results suggesting that monopsonistic/oligopsonistic power in the labor market leads to positive effects of minimum wages to employment.

Nevertheless, other studies reaffirmed the negative relationship between minimum wage and employment (Neumark and Wascher, 1992) and the debate remained opened.

Subsequent recent research also showed mixed results. Meer and West (2016) found that the minimum wage reduces job growth over a period of several years. Karabarbounis et al. (2023) using synthetic difference-in-differences methods, found that the increase in the minimum wage decreased substantially restaurant and retail employment, even after accounting for potential confounding effects from the pandemic and civil unrest. Paun (2021) analyzed the relation between the dynamics of minimum wages and that of employment in 20 EU countries, as well as Australia and Turkey, using panel data (1999–2016) and the results suggest a negative impact of the minimum wage on total employment and on sensitive categories (e.g., youth, female workers, and the elderly).

On the other hand, Sturn (2018), for a sample of 19 OECD countries with data until 2013, finds little evidence of substantial disemployment effects for low-skilled, female low-skilled, or young workers. The estimated employment elasticities are small and statistically indistinguishable from zero. Cengiz et al. (2019), using a difference-in-difference approach, found that the overall number of low-wage jobs remained essentially unchanged over the five years following the increase. Azar et al. (2024) show that in the most concentrated labor markets, employment rises following a minimum wage increase. A model of oligopsonistic competition can explain these effects since there is more room to increase wages in high-concentration areas where wages tend to be further below marginal productivity.

Christl et al. (2018), using panel data for period 1980–2011 for 12 EU countries, find a nonlinear relationship between minimum wages and employment rate of young individuals. Therefore, low minimum wages seem to have a positive relationship with employment, but above a certain level this relationship turns negative. That negative effect is stronger when labor markets are strictly regulated and workers are less productive.

Baily et al. (2021) found that the 1966 Fair Labor Standards Act increased wages dramatically but reduced aggregate employment only modestly. Similarly, Giupponi et al. (2024) assess the impact of nationwide wages on employment and find a substantial increase in wages at the bottom of the wage distribution, while they detect a small, statistically insignificant negative effect on employment.

Moreover, there are empirical minimum wage studies for individual European countries, like Germany and UK. Specifically, Bossler & Gerner (2020) and Bossler et al. (2025) show that in Germany the introduction of a national minimum wage had a modest negative effect on overall employment and working hours and there was also a decline in minijobs. Employment effects are due to reduced hirings rather than the increase of layoffs. For UK, a meta-analysis by de Linde Leonard et al. (2014) showed that an increase of minimum wage had practically insignificant negative effects on employment. However, the increase of minimum wage had a specific negative effect at the residential home care sector, a result which also aligns with the work of Machin et al. (2003).

In light of the diverse and often conflicting empirical findings, the employment effects of minimum wage policies remain an open question in the economic literature. While some studies highlight potential disemployment effects, others suggest neutral or even positive outcomes, particularly in markets characterized by imperfect competition. This persistent ambiguity underscores the importance of continued empirical investigation to better understand the nuanced impacts of minimum wage adjustments across different labor market contexts. This study advances the existing literature by providing a robust empirical analysis of the minimum wage-unemployment nexus within the EU context. For instance, while Paun (2021) employs EU panel data from 1999–2016 to document negative impacts on employment, particularly for vulnerable groups like youth and low-skilled workers, our analysis extends the time span to 2000–2023, capturing recent macroeconomic shocks such as the COVID-19 pandemic, and focuses on unemployment dynamics as the primary outcome. Unlike Paun (2021), which uses fixed and random effects models without explicitly addressing endogeneity, we employ dynamic system GMM estimators to control for potential endogeneity. Furthermore, while Sturn (2018) employs a similar methodological framework (fixed effects and system GMM) and finds minimal disemployment effects in a broader OECD sample, our EU-focused approach accounts for distinct institutional factors, such as harmonized monetary policies and fiscal constraints, and incorporates additional controls, including inflation volatility, long-term interest rates, and government effectiveness. Through GMM and robustness checks on employment rates and vulnerable subgroups, we reconcile mixed findings in prior studies, offering evidence of disemployment effects, albeit economically modest, that inform EU policy trade-offs between wage equity and labor market efficiency.

3. Empirical strategy and data

To examine the relationship between minimum wage and unemployment, we estimate a baseline panel model with fixed cross-sectional and period effects, where the minimum wage variable is introduced in two alternative specifications. Specifically, we use (i) the average monthly minimum wage across the first and second semesters of each year (MW_av) and (ii) the monthly minimum wage in the second semester (MW_*end*), which reflects the end-of-year level[1]. The model is specified as follows:

$$Unemp_{i,t} = \beta_0 + \beta_1 MW^{(k)}{}_{i,t-1} + \beta_2 X_{i,t-1} + \delta_i + \gamma_t + \varepsilon_{i,t} \quad (1)$$

where $Unemp$ is the total unemployment rate as a percentage of the labor force $MW^{(k)}$ denotes the minimum wage variable, with $k = 1$ for the average of the two semesters (MW_av) and $k = 2$ for the second semester value (MW_*end*).

[1] Two different minimum wage variables are used because EUROSTAT provides data semi-annually, requiring conversion to an annual format. The first variable, MW_av (average monthly minimum wage), captures the overall yearly minimum wage. The second, MW_end (monthly minimum wage in the second semester), represents the minimum wage level at the end of the year, which includes more recent policy changes. This dual approach helps explore different potential impacts of minimum wage policies (e.g., the full year's effect versus the effect of later changes).

Furthermore, $X_{i,t-1}$ is a vector of country-specific characteristics potentially affecting unemployment rates. To account for these characteristics, a variety of control variables are utilized. First, the annual growth rate of real GDP *(GDPG)* is incorporated to capture the cyclical relationship between economic output and unemployment (Brecher and Gross, 2018; Ramos-Herrera, 2023).

Additionally, inflation volatility (*HICPV*) is introduced as a control variable, following Friedman's (1977) argument that inflation volatility can hinder economic activity by increasing the recorded unemployment rate (Fountas et al., 2006; Živkov et al., 2020). However, it is also possible that rising inflation volatility reflects a surge in demand, which could have a positive effect on employment. Inflation volatility is measured as the standard deviation of year-on-year inflation rates over a three-year period (Blanchard and Simon, 2001).

To capture the fiscal dimension, we include the public debt-to-GDP ratio (*DEBT*) in the model (Battaglini and Coate, 2016; Ramos-Herrera, 2023). A higher debt ratio may indicate fiscal constraints or expansionary fiscal policies, each of which could influence unemployment in different directions.

To account for monetary policy effects, we include the long-term interest rate (*LTIR*), proxied by the yield on 10-year government bonds. This variable reflects the overall stance of monetary policy, as long-term rates affect borrowing costs, investment decisions, and ultimately labor market outcomes (Lepetit, 2020; Gabriel, 2023).

Government effectiveness (*GOV_ef*) is also considered, as it may significantly shape labor market outcomes (Boţa-Avram, 2021; Sahnoun and Abdennadher, 2023). Effective governance is expected to support labor market performance and reduce unemployment.

Last, the labor productivity (LPROD) is also expected to affect unemployment (Paun et al., 2021; Ramos-Herrera, 2023). The impact may be positive, leading to the creation of new positions, but it could also negatively affect specific groups of employees, such as those whose skills become redundant due to automation or technological advancements.

Since unemployment is a lagging economic indicator—meaning changes in underlying factors often require time to fully materialize in labor market data—we apply a one-year lag to all independent variables in our model. This approach reflects the delayed transmission of economic and institutional shocks to unemployment figures. Relevant panel data studies on minimum wage effects (Baker et al., 1999; Burkhauser et al., 2000; Keil et al., 2001) also seems to support that lags do matter since firms adjust their employment levels well after an increase in the minimum wage. Additionally, introducing a lag helps to mitigate potential simultaneity bias, thereby supporting a more robust estimation of the causal relationships being investigated.

While some empirical studies suggest that the effects of minimum wage changes are concentrated in the first two quarters following implementation (e.g., Cengiz et al., 2019), other strands of the literature emphasize that such effects may take longer to materialize, particularly in highly regulated labor markets. For instance, Christl et al. (2018), Neumark and Wascher (2004), and Baker et al. (1999) argue that due to strong employment protection and institutional rigidities characteristic of European labor markets-firms often adjust their employment decisions with a delay. From a theoretical perspective, the adjustment to changes in factor prices, such as wages, requires time, further supporting the use of annual data in empirical models. Since our analysis focuses exclusively on European countries, where labor markets are more regulated, a delayed response is both theoretically and empirically expected.

Finally, δ_i represents country fixed effects, which control for unobserved cross-country heterogeneity, γ_t denotes time fixed effects to account for common temporal shocks, and $\varepsilon_{i,t}$ is the idiosyncratic error term.

To assess the impact of exogenous shocks on unemployment in Europe, the model is extended to include shocks that have significantly affected European economies: the three major crises—the Global Financial Crisis (2007–2008), the European Debt Crisis (2010–2013), and the COVID-19 pandemic (2020–2022). Additionally, we examine the effects of economic adjustment programs implemented during the European debt crisis. Five EU countries [2] entered memorandums of understanding (MoUs) requiring strict austerity measures that significantly impacted their labor markets. The extended model incorporating these exogenous shocks is specified as follows:

$$Unemp_{i,t} = \beta_0 + \beta_1 MW^{(k)}{}_{i,t-1} + \beta_2 X_{i,t-1} + \beta_3 EX^{(n)}{}_{i,t} + \delta_i + \gamma_t + \varepsilon_{i,t} \quad (2)$$

where $EX^{(n)}$ denotes the exogenous shocks. Specifically, n=*1* represents a dummy variable for crises, taking a value of one for the years 2008 to 2013 (encompassing the GFC and EDC) and for the years 2020 to 2022 (representing the Covid-19 crisis), and zero otherwise. Additionally, n = 2 is a dummy variable for MoU, which takes the value of one for country-years when these adjustment programs were in effect, and zero otherwise (including for countries that never entered such programs).

As an extension of the exogenous shocks model, an alternative specification was also considered in which the aggregated crisis dummy is replaced with separate indicators for each major economic shock, allowing potential differences in the timing and nature of individual crisis episodes to be captured more precisely. Specifically, we introduced distinct dummy variables for the global financial crisis (2008–2009), the European debt crisis (2010–2013), and the COVID-19 pandemic (2020–2021), excluding 2022 due to its limited labor market impact.

Our dataset comprises annual data spanning the period from 2000 to 2023 for 21 member countries of the EU [3], resulting in an unbalanced panel. The macroeconomic data, including unemployment rates, GDP growth, inflation, long-term interest rates, public debt to GDP ratio, labor productivity and minimum wages, are sourced from the EUROSTAT database. The government effectiveness variable is drawn from the World Bank, world governance indicators database (Table A.1).

4. Results

Table 1 presents the estimation results from our baseline panel data models (Eqs. 1 and 2), examining the determinants of unemployment in 21 EU member countries between 2000 and 2023.

[2] Greece, Ireland, Portugal, and Cyprus implemented full economic adjustment programs governed by MoUs during the European debt crisis. Spain entered a more limited financial assistance arrangement.

[3] The dataset deviates from the full EU-27 membership due to the exclusion of countries for which minimum wage data is unavailable in the EUROSTAT database. Specifically, Denmark, Italy, Cyprus, Austria, Finland, and Sweden are not included in the analysis.

Table 1. Baseline models with country and time fixed effects.

Dependent Variable: Unemp	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
GDPG (t-1)			−0.0805**	−0.0801**	−0.0805**	−0.0801**	−0.0807**	−0.0804**
			(0.0392)	(0.0392)	(0.0392)	(0.0392)	(0.0384)	(0.0384)
HICPV (t-1)			0.561***	0.562***	0.561***	0.562***	0.571***	0.572***
			(0.127)	(0.127)	(0.127)	(0.127)	(0.124)	(0.124)
DEBT (t-1)			0.0566***	0.0567***	0.0566***	0.0567***	0.0513***	0.0513***
			(0.00846)	(0.00847)	(0.00846)	(0.00847)	(0.00838)	(0.00839)
LTIR (t-1)			0.663***	0.669***	0.663***	0.669***	0.526***	0.533***
			(0.0771)	(0.0772)	(0.0771)	(0.0772)	(0.0823)	(0.0824)
GOV_ef (t-1)			−2.700***	−2.715***	−2.700***	−2.715***	−2.416***	−2.429***
			(0.678)	(0.678)	(0.678)	(0.678)	(0.667)	(0.668)
LPROD (t-1)			−0.0499***	−0.0493***	−0.0499***	−0.0493***	−0.0546***	−0.0541***
			(0.0143)	(0.0143)	(0.0143)	(0.0143)	(0.0140)	(0.0140)
MW_av (t-1)	0.00584***		0.00306**		0.00306**		0.00270*	
	(0.00213)		(0.00151)		(0.00151)		(0.00148)	
MW_end (t-1)		0.00491**		0.00307**		0.00307**		0.00267*
		(0.00214)		(0.00151)		(0.00151)		(0.00148)
Crises					0.249	0.267		
					(1.386)	(1.379)		
MoU							2.599***	2.592***
							(0.622)	(0.623)
Constant	7.093***	7.491***	6.116***	6.016***	6.116***	6.016***	7.560***	7.487***
	(1.172)	(1.182)	(1.658)	(1.676)	(1.658)	(1.676)	(1.660)	(1.679)
Observations	460	460	429	429	429	429	429	429
R-squared	0.355	0.352	0.718	0.718	0.718	0.718	0.730	0.730
Countries	21	21	21	21	21	21	21	21

Note: This table presents the estimation results for the baseline model described in Eq. (1) and Eq. (2). Standard errors in parentheses. The ***, **, and * denote statistical significance at the 1%, 5% and 10% level, respectively

Our analysis identifies a statistically significant and positive relationship between the minimum wage in the previous year and the current unemployment rate. Specifically, both the lagged average monthly minimum wage (MW_av) and the lagged minimum wage in the second semester (MW_end) are associated with higher unemployment rates (Columns 3 and 4). This result aligns with neoclassical theoretical predictions that higher wage floors may reduce labor demand[4]. This relationship persists even after controlling for major economic shocks (2008 global financial crisis, 2010–2013 European debt crisis and Covid pandemic) and structural adjustment programs (Columns 5–8).

[4] We also re-estimated the fixed effects models excluding all macroeconomic controls. The results (Table 1, Columns 1–2) show that the minimum wage coefficients remain consistent in sign and statistical significance, indicating that the observed relationships are not solely dependent on the inclusion of the control variable set. These concerns are more thoroughly addressed when the system GMM estimator is employed in Section 5.

Table 2. Exogenous shocks models with separate crises episodes with country and time fixed effects.

Dependent Variable: Unemp	(1)	(2)	(3)	(4)	(5)	(6)
GDPG (t-1)	−0.0805**	−0.0801**	−0.0805**	−0.0801**	−0.0805**	−0.0801**
	(0.0392)	(0.0392)	(0.0392)	(0.0392)	(0.0392)	(0.0392)
HICPV (t-1)	0.561***	0.562***	0.561***	0.562***	0.561***	0.562***
	(0.127)	(0.127)	(0.127)	(0.127)	(0.127)	(0.127)
DEBT (t-1)	0.0566***	0.0567***	0.0566***	0.0567***	0.0566***	0.0567***
	(0.00846)	(0.00847)	(0.00846)	(0.00847)	(0.00846)	(0.00847)
LTIR (t-1)	0.663***	0.669***	0.663***	0.669***	0.663***	0.669***
	(0.0771)	(0.0772)	(0.0771)	(0.0772)	(0.0771)	(0.0772)
GOV_ef (t-1)	−2.700***	−2.715***	−2.700***	−2.715***	−2.700***	−2.715***
	(0.678)	(0.678)	(0.678)	(0.678)	(0.678)	(0.678)
LPROD (t-1)	−0.0499***	−0.0493***	−0.0499***	−0.0493***	−0.0499***	−0.0493***
	(0.0143)	(0.0143)	(0.0143)	(0.0143)	(0.0143)	(0.0143)
MW_av (t-1)	0.00306**		0.00306**		0.00306**	
	(0.00151)		(0.00151)		(0.00151)	
MW_end (t-1)		0.00307**		0.00307**		0.00307**
		(0.00151)		(0.00151)		(0.00151)
C2008	2.027**	2.019**				
	(0.902)	(0.903)				
C2010			3.189***	3.202***		
			(1.015)	(1.012)		
Covid					−0.0539	−0.0198
					(1.446)	(1.436)
Constant	6.116***	6.016***	6.116***	6.016***	6.116***	6.016***
	(1.658)	(1.676)	(1.658)	(1.676)	(1.658)	(1.676)
Observations	429	429	429	429	429	429
R-squared	0.718	0.718	0.718	0.718	0.718	0.718
Countries	21	21	21	21	21	21

Note: This table presents the estimation results for the baseline model described in Eq. (1) and Eq. (2). Standard errors in parentheses. The ***, **, and * denote statistical significance at the 1%, 5%, and 10% level, respectively.

The estimates obtained from the specification with separate crisis dummies (Table 2) remain consistent with our baseline results, suggesting that the observed relationship between minimum wage changes and unemployment is not sensitive to the specification of crisis periods.

It is important to note that while statistically significant, these coefficients are relatively small in magnitude, suggesting an economically modest impact of minimum wage changes on unemployment within our sample. This indicates that an increase in the minimum wage in the prior year is associated with only a slightly higher unemployment rate in the current year. More specifically, our findings indicate that a 100 euro increase in the minimum wage is associated with an average increase in the unemployment rate of approximately 0.5 percentage points. Given that the median minimum wage in our sample is 545 euros (Table A.2), this 100 euro increment represents a substantial increase of nearly

20%. The resulting modest impact on unemployment, despite such a considerable wage adjustment, underscores the limited disemployment effects observed in our analysis.

Turning to the control variables, the results consistently show that GDPG and labor productivity (LPROD) are negatively and significantly associated with unemployment, indicating that stronger economic performance and higher productivity contribute to lower unemployment rates. Similarly, government effectiveness is negatively correlated with unemployment, implying that better governance is linked to improved labor market outcomes. Conversely, inflation volatility (HICPV), the public debt-to-GDP ratio (DEBT), and long-term interest rates (LTIR) all exhibit positive and statistically significant relationships with unemployment. These findings suggest that macroeconomic instability, fiscal imbalances, and tighter financial conditions are associated with higher unemployment levels.

5. Robustness tests

5.1. Employment and youth/low-skilled unemployment

To assess the robustness of our baseline findings, we conduct several supplementary analyses. First, to confirm whether the minimum wage exhibits similar impacts on broader labor market dynamics, we re-estimated our baseline model using the employment rate (*Employ*) as the dependent variable instead of the unemployment rate as below:

$$Employ_{i,t} = \beta_0 + \beta_1 MW^{(k)}{}_{i,t-1} + \beta_2 X_{i,t-1} + \delta_i + \gamma_t + \varepsilon_{i,t} \quad (3)$$

This alternative specification allows us to assess if the identified effects on unemployment are mirrored in corresponding changes in employment levels. If higher minimum wages reduce labor demand, we would expect a negative association with employment, consistent with the neoclassical perspective and our baseline results.

Furthermore, acknowledging that certain demographic groups may be more susceptible to the effects of minimum wage changes, we specifically examined the unemployment rate for youth and low-education individuals (*LS_Y_Unemp)*:

$$LS\_Y\_Unemp_{i,t} = \beta_0 + \beta_1 MW^{(k)}{}_{i,t-1} + \beta_2 X_{i,t-1} + \delta_i + \gamma_t + \varepsilon_{i,t} \quad (4)$$

According to existing literature (Brown et al., 1982, 1983; Sturn, 2018; Paun, 2021), these groups are often disproportionately affected by increases in the minimum wage. This targeted analysis helps us ascertain whether our observed relationships are particularly pronounced for vulnerable segments of the labor market. A significant positive relationship here would suggest that minimum wage hikes disproportionately affect these workers.

Table 3. Alternative dependent variables in fixed effects models (employment rate, youth/low-skilled, low-skilled, and youth unemployment).

Dependent Variable: Employ	(1)	(2)	Dependent Variable: LS_Y_Unemp	(3)	(4)	Dependent Variable: LS_Unemp	(5)	(6)	Dependent Variable: Y_Unemp	(7)	(8)
GDPG (t-1)	0.0523	0.0510	GDPG (t-1)	−0.0693	−0.0682	GDPG (t-1)	−0.173**	−0.173**	GDPG (t-1)	−0.197**	−0.196**
	(0.0382)	(0.0382)		(0.128)	(0.128)		(0.0749)	(0.0749)		(0.0816)	(0.0816)
HICPV (t-1)	−0.407***	−0.409***	HICPV (t-1)	1.271***	1.276***	HICPV (t-1)	1.027***	1.028***	HICPV (t-1)	0.828***	0.832***
	(0.124)	(0.124)		(0.410)	(0.410)		(0.243)	(0.243)		(0.265)	(0.265)
DEBT (t-1)	−0.124***	−0.124***	DEBT (t-1)	0.208***	0.208***	DEBT (t-1)	0.104***	0.104***	DEBT (t-1)	0.123***	0.123***
	(0.00825)	(0.00824)		(0.0273)	(0.0273)		(0.0162)	(0.0162)		(0.0176)	(0.0176)
LTIR (t-1)	−0.271***	−0.284***	LTIR (t-1)	1.079***	1.099***	LTIR (t-1)	0.632***	0.640***	LTIR (t-1)	1.197***	1.219***
	(0.0752)	(0.0751)		(0.249)	(0.249)		(0.147)	(0.147)		(0.161)	(0.161)
GOV_ef (t-1)	2.440***	2.475***	GOV_ef (t-1)	−7.508***	−7.549***	GOV_ef (t-1)	−4.580***	−4.600***	GOV_ef (t-1)	−5.960***	−6.008***
	(0.661)	(0.660)		(2.198)	(2.200)		(1.295)	(1.295)		(1.411)	(1.412)
LPROD (t-1)	0.0261*	0.0248*	LPROD (t-1)	−0.162***	−0.160***	LPROD (t-1)	−0.0363	−0.0356	LPROD (t-1)	−0.0453	−0.0434
	(0.0139)	(0.0139)		(0.0467)	(0.0467)		(0.0272)	(0.0272)		(0.0297)	(0.0297)
MW_av (t-1)	−0.00627***		MW_av (t-1)	0.00928*		MW_av (t-1)	0.00354		MW_av (t-1)	0.0102***	
	(0.00147)			(0.00486)			(0.00288)			(0.00313)	
MW_end (t-1)		−0.00646***	MW_end (t-1)		0.00916*	MW_end (t-1)		0.00366	MW_end (t-1)		0.0102***
		(0.00147)			(0.00486)			(0.00288)			(0.00314)
Constant	66.65***	66.92***	Constant	22.97***	22.73***	Constant	10.63***	10.46***	Constant	8.606**	8.296**
	(1.617)	(1.632)		(5.478)	(5.532)		(3.168)	(3.201)		(3.453)	(3.490)
Observations	429	429	Observations	423	423	Observations	429	429	Observations	429	429
R-squared	0.842	0.842	R-squared	0.593	0.593	R-squared	0.601	0.601	R-squared	0.690	0.690
Countries	21	21	Countries	21	21	Countries	21	21	Countries	21	21

Note: This table presents the estimation results for the models described in Eq. (3) and Eq. (4). Standard errors in parentheses. The ***, **, and * denote statistical significance at the 1%, 5%, and 10% level, respectively.

Consistent with our baseline findings on total unemployment, the results in Columns (1) and (2) of Table 3 show a statistically significant and negative relationship between the lagged minimum wage variables (both MW_av and MW_end) and the employment rate. This indicates that increases in the minimum wage in the prior year are associated with a decrease in the overall employment rate, further supporting the neoclassical prediction that higher wage floors can reduce labor demand. While statistically significant, the magnitudes of these coefficients are relatively small, similar to what our baseline results showed for overall unemployment.

When examining the unemployment rate for youth and low-skilled individuals (LS_Y_Unemp) in Columns (3) and (4), we observe a statistically significant and positive relationship with the lagged minimum wage variables. This finding suggests that higher minimum wages negatively affect these vulnerable groups, leading to increased unemployment among them. This outcome is consistent with the baseline results, which also indicated modest negative effects of minimum wage increases on the broader labor market, and aligns with the literature stating that youth and less educated individuals are more susceptible to adverse labor market outcomes when minimum wages rise.

It is important to note that while the estimated coefficients for youth and low-skilled unemployment are larger than those for the general population, this difference reflects the higher baseline unemployment rate among these groups. Specifically, a 100 euro increase in the minimum wage is associated with an average increase of approximately 0.93 percentage points in youth/low-skilled unemployment, compared to 0.5 percentage points for the general unemployment rate. Given that the average youth/low-skilled unemployment rate in our sample is 29.5% (see Table A.2), this effect remains modest in proportional terms, reinforcing the limited disemployment impact observed across demographic groups.

To further analyze the effects of minimum wage changes on youth and low-skilled unemployment, we examine these two groups separately. The results in Table 3 reveal an important distinction: the significant positive relationship between minimum wage and unemployment observed for the composite group (Columns 3 and 4) is primarily driven by its impact on young workers (Columns 7 and 8), where both minimum wage measures are positive and statistically significant. In contrast, for the low-skilled population across all ages (Columns 5 and 6), the coefficients are positive but statistically insignificant in the static fixed effects model. This initial finding suggests that the adverse impact of minimum wage increases may be concentrated among younger individuals.

The control variables exhibit patterns broadly aligned with our baseline results. GDP growth (*GDPG*) and labor productivity (*LPROD*) continue to be negatively and significantly associated with both unemployment rates (total and youth/low-skilled) and positively with the employment rate, underscoring the positive impact of economic performance and productivity on labor market outcomes. Conversely, inflation volatility (*HICPV*), public debt-to-GDP ratio (*DEBT*), and long-term interest rates (*LTIR*) consistently exhibit a negative relationship with the employment rate and a positive correlation with both unemployment rates, suggesting that macroeconomic instability, fiscal imbalances, and tighter monetary conditions are detrimental to labor market performance. Finally, government effectiveness (*GOV_ef*) consistently shows a positive and significant relationship with the employment rate and a negative one with both unemployment rates, emphasizing the crucial role of good governance in fostering healthy labor markets.

5.2. Endogeneity and dynamic persistence: A system GMM estimation

The key identification assumption in our fixed effects specifications is that, conditional on the included control variables and fixed effects, changes in the minimum wage are exogenous to changes in unemployment. While country and time fixed effects absorb a substantial amount of unobserved heterogeneity, this assumption may be violated if time-varying factors uncaptured by our controls influence both minimum wage setting and unemployment dynamics. To further validate the robustness of our findings and address these potential endogeneity concerns, as well as dynamic persistence in unemployment, we re-estimate all specifications using a GMM estimator for dynamic panel models.(Arellano & Bond, 1991; Blundell & Bond, 1998).

This approach is particularly suited to our context for three key reasons. First it explicitly accounts for the dynamic persistence of unemployment by including a lagged dependent variable, which standard fixed effects estimators handle poorly due to Nickell (1981) bias. Second it addresses the potential reverse causality, as policymakers may adjust minimum wages in response to labor market conditions. Third it accounts for additional endogeneity concerns since unobserved institutional or policy shocks may correlate with both unemployment and wage-setting decisions.

In our estimation, the minimum wage variable, the macroeconomic controls and the lagged dependent variable are treated as endogenous. The instrumentation strategy uses lagged levels of these variables as instruments for their first differences, and lagged differences as instruments for their levels, with one lag for the differenced equation and up to two lags for the level equation. To mitigate instrument proliferation, we restrict lag depth to two and apply robust standard errors. The validity of the instrument set is supported by the Sargan test of overidentifying restrictions (Tables 4, 5, and 6).

Table 4 focuses on the unemployment rate (*Unemp*) as the dependent variable across various specifications, including the impact of major economic crises and adjustment programs. The results consistently show a statistically significant and positive effect of the lagged minimum wage variables (MW_av and MW_end) on unemployment. This reinforces our earlier fixed-effects findings that higher minimum wages are associated with increased unemployment, even after addressing dynamic endogeneity. The lagged dependent variable (Unemp (t-1)) is highly significant across all models, confirming the strong persistence in unemployment rates.

The coefficients for control variables largely maintain their expected signs and significance: GDPG reduces unemployment, while debt and interest rates exacerbate it, though government effectiveness and productivity lose significance in these specifications. The aggregated "Crises" dummy variable (Columns 3 and 4) is also positive and statistically significant, indicating that periods encompassing the global financial crisis, the European debt crisis, and the COVID-19 pandemic significantly exacerbated unemployment. Conversely, the significance of the MoU dummy varies, suggesting a more nuanced impact when accounting for dynamic effects and instrumenting for endogeneity.

Table 4. System GMM estimates: Minimum wage effects on unemployment rates.

Dependent Variable: Unemp	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Unemp (t-1)	0.883***	0.891***	0.706***	0.827***	0.855***	0.851***	0.864***	0.826***
	(0.134)	(0.126)	(0.159)	(0.135)	(0.142)	(0.133)	(0.225)	(0.169)
GDPG (t-1)	−0.108***	−0.110***	−0.0719***	−0.0807***	−0.111***	−0.107***	−0.104***	−0.112***
	(0.0226)	(0.0285)	(0.0149)	(0.0217)	(0.0273)	(0.0235)	(0.0306)	(0.0312)
HICPV (t-1)	−0.173**	−0.187*	0.0604	−0.0119	−0.199	−0.225**	−0.161*	−0.170**
	(0.0735)	(0.106)	(0.129)	(0.0888)	(0.135)	(0.113)	(0.0863)	(0.0794)
DEBT (t-1)	−0.0605**	−0.0620**	−0.0300	−0.0407	−0.0647*	−0.0556**	−0.0625**	−0.0572**
	(0.0260)	(0.0293)	(0.0243)	(0.0257)	(0.0333)	(0.0239)	(0.0314)	(0.0264)
LTIR (t-1)	0.379***	0.369***	0.407***	0.349**	0.366***	0.444***	0.377***	0.371***
	(0.114)	(0.108)	(0.0995)	(0.139)	(0.132)	(0.170)	(0.116)	(0.111)
GOV_ef (t-1)	0.887	0.439	9.318	5.320	1.215	2.012	0.996	1.635
	(2.670)	(2.922)	(6.498)	(4.629)	(3.337)	(3.264)	(3.601)	(3.470)
LPROD (t-1)	−0.0226	−0.0192	−0.0257	−0.0219	−0.0249	−0.0226	−0.0152	−0.0142
	(0.0255)	(0.0303)	(0.0221)	(0.0284)	(0.0271)	(0.0288)	(0.0328)	(0.0344)
MW_av (t-1)	0.00752***		0.00379**		0.00794***		0.00738***	
	(0.00165)		(0.00180)		(0.00301)		(0.00218)	
MW_end (t-1)		0.00738***		0.00365*		0.00694***		0.00700***
		(0.00261)		(0.00191)		(0.00201)		(0.00247)
Crises			0.893***	0.818***				
			(0.205)	(0.242)				
MoU					0.610	−0.330		
					(1.207)	(1.914)		
Elect (t-1)							−0.123	0.195
							(0.442)	(0.819)
Gov_new (t-1)							0.0964	0.0886
							(0.653)	(0.642)
Constant	−1.045	−0.593	−7.114	−3.741	−0.661	−2.083	−1.545	−1.681
	(2.853)	(3.127)	(6.247)	(4.691)	(4.027)	(4.143)	(3.184)	(3.393)
Observations	398	398	398	398	398	398	396	396
Countries	21	21	21	21	21	21	21	21
Sargan (Prob.)	0.446	0.413	0.757	0.608	0.435	0.540	0.449	0.461

Note: This table presents the estimation results of the System GMM. Standard errors in parentheses. The ***, ** and * denote statistical significance at the 1%, 5% and 10% level, respectively. Sargan p > 0.10 supports instrument validity.

Table 5. System GMM estimates: Exogenous shocks models with separate crises episodes.

Dependent Var: Unemp	(1)	(2)	(3)	(4)	(5)	(6)
Unemp (t-1)	0.948***	1.008***	0.829***	0.845***	0.908***	0.881***
	(0.165)	(0.149)	(0.124)	(0.135)	(0.147)	(0.0976)
GDPG (t-1)	−0.101***	−0.108***	−0.0954***	−0.0922**	−0.101***	−0.0985***
	(0.0316)	(0.0249)	(0.0233)	(0.0423)	(0.0370)	(0.0324)
HICPV (t-1)	−0.111	−0.134	−0.133	−0.160**	−0.153*	−0.0522
	(0.105)	(0.0820)	(0.0996)	(0.0801)	(0.0815)	(0.132)
DEBT (t-1)	−0.0523*	−0.0629**	−0.0541**	−0.0537**	−0.0626**	−0.0466
	(0.0311)	(0.0295)	(0.0249)	(0.0244)	(0.0284)	(0.0288)
LTIR (t-1)	0.330**	0.264**	0.344***	0.332***	0.389***	0.406***
	(0.134)	(0.105)	(0.113)	(0.112)	(0.126)	(0.0961)
GOV_ef (t-1)	4.066	0.986	1.642	0.304	0.949	1.137
	(5.004)	(3.251)	(2.749)	(2.931)	(2.816)	(2.860)
LPROD (t-1)	−0.0399	−0.0398	−0.0229	−0.0319	−0.0167	−0.0137
	(0.0430)	(0.0414)	(0.0279)	(0.0424)	(0.0262)	(0.0251)
MW_av (t-1)	0.00756*		0.00646***		0.00740***	
	(0.00389)		(0.00176)		(0.00211)	
MW_end (t-1)		0.00893***		0.00653***		0.00497*
		(0.00305)		(0.00225)		(0.00263)
C2008	1.391***	1.313***				
	(0.312)	(0.461)				
C2010			0.522	0.459		
			(0.391)	(0.434)		
Covid					0.161	−0.482
					(0.773)	(0.975)
Constant	−4.352	−1.256	−0.700	1.093	−1.615	−1.567
	(4.766)	(3.743)	(3.281)	(4.209)	(3.097)	(3.150)
Observations	398	398	398	398	398	398
Countries	21	21	21	21	21	21
Sargan (Prob.)	0.587	0.436	0.477	0.439	0.457	0.619

Note: This table presents the estimation results of the System GMM. Standard errors in parentheses. The ***, ** and * denote statistical significance at the 1%, 5% and 10% level, respectively. Sargan $p > 0.10$ supports instrument validity.

Table 5 presents the results of the alternative specification that replaces the aggregated crisis dummy with separate indicators for the global financial crisis (C2008), the European debt crisis (C2010), and the COVID-19 pandemic (Covid). The coefficient on the lagged minimum wage variable remains positive and statistically significant across these models, confirming that our findings are not sensitive to how we specify crisis periods. While the individual crisis dummies themselves are all positive, only the C2008 and C2010 dummies are statistically significant, highlighting that these periods had a more pronounced and lasting effect on unemployment compared to the Covid-19 crisis.

Table 6. System GMM estimates: Minimum wage effects on employment rates (Employ), low-skilled youth unemployed (LS_Y_Unemp), low-skilled unemployment (LS_Unemp), and youth unemployment (Y_Unemp).

Dependent Var: Employ	(1)	(2)	Dependent Variable: LS_Y_Unemp	(3)	(4)	Dependent Variable: LS_Unemp	(5)	(6)	Dependent Variable: Y_Unemp	(7)	(8)
GDPG (t-1)	0.0890***	0.0927***	GDPG (t-1)	−0.170	−0.255**	GDPG (t-1)	−0.0829	−0.118*	GDPG (t-1)	−0.210**	−0.136
	(0.0242)	(0.0224)		(0.131)	(0.111)		(0.112)	(0.0614)		(0.0858)	(0.114)
HICPV (t-1)	0.0807	0.102	HICPV (t-1)	−0.523	−0.415	HICPV (t-1)	−0.203**	−0.220*	HICPV (t-1)	−0.474*	−0.443*
	(0.0708)	(0.0706)		(0.412)	(0.357)		(0.102)	(0.122)		(0.242)	(0.242)
DEBT (t-1)	0.0634***	0.0615***	DEBT (t-1)	−0.133**	−0.125	DEBT (t-1)	−0.0911*	−0.0911**	DEBT (t-1)	−0.147	−0.134**
	(0.0244)	(0.0201)		(0.0676)	(0.0801)		(0.0506)	(0.0444)		(0.0923)	(0.0663)
LTIR (t-1)	−0.235*	−0.254*	LTIR (t-1)	0.905*	0.830*	LTIR (t-1)	0.562***	0.704***	LTIR (t-1)	0.706**	0.630**
	(0.136)	(0.133)		(0.494)	(0.429)		(0.174)	(0.205)		(0.276)	(0.271)
GOV_ef (t-1)	−0.447	−0.699	GOV_ef (t-1)	8.887	5.068	GOV_ef (t-1)	6.215	9.278	GOV_ef (t-1)	−0.758	−4.678
	(3.537)	(3.774)		(15.43)	(14.21)		(6.800)	(7.732)		(6.247)	(6.913)
LPROD (t-1)	0.0399	0.0364	LPROD (t-1)	−0.289	−0.125	LPROD (t-1)	−0.213	−0.107*	LPROD (t-1)	−0.0487	−0.193
	(0.0437)	(0.0395)		(0.197)	(0.152)		(0.174)	(0.0587)		(0.132)	(0.207)
MW_av (t-1)	−0.00805***		MW_av (t-1)	0.0343***		MW_av (t-1)	0.0172***		MW_av (t-1)	0.0189**	
	(0.00255)			(0.0119)			(0.00642)			(0.00874)	
MW_end (t-1)		−0.00780***	MW_end (t-1)		0.0210*	MW_end (t-1)		0.0121***	MW_end (t-1)		0.0222**
		(0.00230)			(0.0118)			(0.00370)			(0.0106)
Employ (t-1)	1.023***	1.008***	LS_Y_Unemp (t-1)	0.776***	0.763***	LS_Unemp (t-1)	0.780***	0.817***	Y_Unemp (t-1)	0.906***	0.890***
	(0.150)	(0.130)		(0.200)	(0.181)		(0.130)	(0.0984)		(0.203)	(0.137)
Constant	−1.614	−0.161	Constant	4.553	3.414	Constant	7.919	−2.337	Constant	−0.532	15.14
	(13.97)	(12.97)		(21.99)	(18.27)		(9.521)	(8.401)		(10.75)	(19.50)
Observations	398	398	Observations	391	391	Observations	398	398	Observations	398	398
Countries	21	21	Countries	21	21	Countries	21	21	Countries	21	21
Sargan (Prob.)	0.462	0.454	Sargan (Prob.)	0.711	0.537	Sargan (Prob.)	0.648	0.764	Sargan (Prob.)	0.471	0.624

Note: This table presents the estimation results of the System GMM. Standard errors in parentheses. The ***, **, and * denote statistical significance at the 1%, 5%, and 10% level, respectively. Sargan $p > 0.10$ supports instrument validity.

Table 6 extends this analysis to the employment rate (*Employ*) and the unemployment rate for youth and low-skilled employees (*LS_Y_Unemp*). For the employment rate (Columns 1 and 2), the lagged minimum wage variables continue to exhibit a statistically significant negative impact, supporting the notion that minimum wage increases can reduce overall employment. When examining the unemployment rate for youth and low-skilled individuals (Columns 3 and 4), we find a robust, statistically significant positive relationship with the lagged minimum wage. This strengthens our conclusion that these vulnerable groups are disproportionately affected by minimum wage hikes.

To deepen the analysis and account for dynamic labor market adjustments, we examine again the effects of minimum wage increases on youth and low-skilled unemployment separately, using the System GMM approach (Table 6). For the low-skilled group (Columns 5 and 6), the minimum wage coefficients become positive and highly significant. This reversal suggests that the static fixed effects model may not fully account for the persistence of high unemployment rates among low-skilled individuals across periods. Once this dynamic is modeled, a robust disemployment effect for the low-skilled emerges. The effect remains strong and significant for youth unemployment (Columns 7 and 8), confirming the fixed effects result. Consequently, the GMM results demonstrate that the adverse impact of minimum wages is a robust phenomenon for both vulnerable segments of the labor market, not just the youth. The largest coefficients are still observed for the composite group (Columns 3 and 4), indicating that individuals who are both young and low-skilled are the most susceptible to these disemployment effects.

5.3. Controlling for political endogeneity

A concern in the minimum wage literature is that policy changes are not exogenous but are instead influenced by political and economic conditions that may also directly affect unemployment (the problem of non-random treatment assignment). While the GMM estimator addresses endogeneity stemming from dynamic persistence and reverse causality, we further confront the issue of political endogeneity by incorporating controls for the domestic political cycle. Specifically, we augment our GMM models with two additional variables: a dummy for national election years (Elect) and a dummy indicating a year-on-year change in the ideological composition of the governing cabinet (Gov_new) (table A.1). These variables aim to capture political pressures and shifts that could influence both the propensity to enact minimum wage hikes and contemporaneous labor market outcomes.

The results from these extended GMM specifications, which include political cycle controls, remain consistent with our core findings (Table 4, Columns 7 and 8). Across both specifications, the significant positive relationship between the lagged minimum wage and unemployment persists, even after controlling for national elections and shifts in cabinet ideology.

5.4. Leave-One-Out robustness test

To assess the sensitivity of our findings to potential outlier effects and to test whether our overall results are disproportionately influenced by the policies of any single country, we conducted a leave-one-out robustness analysis using the system GMM estimator. In each iteration, one country was excluded from the sample, and the model was re-estimated.

The results of this test (table 7) confirm the robustness of our core finding. The coefficient on the lagged minimum wage variable (MW_av) remains positive, statistically significant, and consistent in magnitude across all iterations. The estimated coefficients range from 0.0065 (when Croatia is excluded) to 0.0083 (when Ireland is excluded), and all remain statistically significant at either the 1% or 5% level. These results provide strong evidence that our findings are not driven by the unique characteristics or policies of any single country.

Table 7. Results of leave-one-out robustness test

	Country excluded	Coefficient (MW_av)	Standard error
1	Belgium	0.0078652***	0.0023397
2	Bulgaria	0.0077023***	0.0022089
3	Croatia	0.0065466***	0.0017966
4	Czech Repu.	0.006937**	0.0028429
5	Estonia	0.0075473***	0.0022913
6	France	0.0076775***	0.0023967
7	Germany	0.0077809***	0.0025668
8	Greece	0.0067596***	0.0018415
9	Hungary	0.0075957**	0.0037794
10	Ireland	0.0082747***	0.0020084
11	Latvia	0.0072335***	0.0015418
12	Lithuania	0.0070767***	0.0021084
13	Luxemburg	0.0079215***	0.0020624
14	Malta	0.0068252**	0.0034094
15	Netherlands	0.0075689***	0.0018989
16	Poland	0.0078725***	0.0030203
17	Portugal	0.0070879***	0.002203
18	Romania	0.0069841**	0.0031061
19	Slovakia	0.0074655***	0.0025112
20	Slovenia	0.0074655***	0.0025112
21	Spain	0.0064872**	0.0029213

Note: This table presents the coefficient and standard error for the lagged minimum wage variable (MW_av) from a leave-one-out robustness test using the System GMM estimator. Each row represents a separate regression where the indicated country was excluded from the sample. The ***, **, and * denote statistical significance at the 1%, 5%, and 10% level, respectively.

6. Further analysis

6.1. Business cycle timing and minimum wage effects

Minimum wage policies are frequently implemented during periods of economic expansion, which raises the possibility that their effects may be confounded by underlying business cycle dynamics. In some extent the inclusion of control macroeconomic variables such as the GDP growth in our baseline regressions account for the effect of business cycle. However, to further examine the role of business cycle timing we extend our analysis in two ways. First, we replaced GDP growth with the output gap, which measures the deviation of actual GDP from its potential level, thus providing a more precise indicator of the economy's cyclical position. Second, we introduce an interaction term between the lagged minimum wage variable and GDP growth to test whether the impact of minimum wage changes varies across different phases of the business cycle.

Table 8. Minimum wage effects on unemployment with business cycle controls and interaction terms.

Dependent Var: Unemp	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Unemp (t-1)			0.765***	0.768***			0.853***	0.902***
			(0.164)	(0.228)			(0.198)	(0.209)
GDPG (t-1)					−0.165***	−0.162***	−0.147***	−0.144***
					(0.0518)	(0.0519)	(0.0460)	(0.0422)
OP_Gap	−0.344***	−0.343***	−0.0495	−0.0520				
	(0.0424)	(0.0423)	(0.0576)	(0.0600)				
HICPV (t-1)	0.425***	0.428***	−0.213***	−0.213***	0.527***	0.530***	−0.173**	−0.193
	(0.119)	(0.119)	(0.0674)	(0.0791)	(0.127)	(0.127)	(0.0736)	(0.119)
DEBT (t-1)	0.0459***	0.0460***	−0.0439**	−0.0453**	0.0579***	0.0581***	−0.0572**	−0.0627*
	(0.00796)	(0.00796)	(0.0183)	(0.0192)	(0.00843)	(0.00844)	(0.0283)	(0.0355)
LTIR (t-1)	0.510***	0.520***	0.506***	0.489***	0.638***	0.644***	0.362***	0.359***
	(0.0716)	(0.0715)	(0.104)	(0.0941)	(0.0773)	(0.0774)	(0.102)	(0.115)
GOV_ef (t-1)	−1.831***	−1.853***	1.052	0.297	−2.721***	−2.740***	0.555	0.272
	(0.631)	(0.631)	(2.244)	(2.611)	(0.673)	(0.674)	(3.400)	(3.363)
LPROD (t-1)	−0.0386***	−0.0378***	−0.0667**	−0.0599*	−0.0599***	−0.0588***	−0.0424	−0.0220
	(0.0133)	(0.0133)	(0.0306)	(0.0351)	(0.0147)	(0.0147)	(0.0490)	(0.0356)
MW_av (t-1)	0.00432***		0.00834***		0.00326**		0.00794***	
	(0.00140)		(0.00221)		(0.00150)		(0.00247)	
MW_end (t-1)		0.00424***		0.00782***		0.00325**		0.00741***
		(0.00140)		(0.00254)		(0.00150)		(0.00250)
GDP (t-1) x MW_av (t-1)					0.000126**		6.35e−05	
					(5.07e−05)		(5.00e−05)	
GDP (t-1) x MW_end (t-1)						0.000122**		4.75e−05
						(5.07e−05)		(4.86e−05)
Constant	5.924***	5.824***	1.507	2.580	7.145***	7.016***	0.880	−0.191
	(1.470)	(1.486)	(3.332)	(2.765)	(1.699)	(1.717)	(4.077)	(3.248)
Observations	429	429	398	398	429	429	398	398
Countries	21	21	21	21	21	21	21	21
R-squared	0.757	0.757			0.723	0.722		
Sargan (Prob.)			0.467	0.412			0.468	0.418

Note: This table presents the estimation results of the fixed effects (Columns 1, 2, 5, and 6) and System GMM (Columns 3, 4, 7, and 8) models. Standard errors are in parentheses. The ***, **, and * denote statistical significance at the 1%, 5%, and 10% level, respectively. A Sargan test p-value greater than 0.10 supports the validity of the instruments used in the GMM specifications.

The results (Table 8) show that the minimum wage variables remain positive and statistically significant across all specifications, including those that use the output gap as a control (Columns 1–4) and interaction terms (Columns 5–8). The negative sign of the output gap is consistent with economic theory: a positive output gap, which indicates an overheated economy is negatively correlated with unemployment, while a negative output gap during a recession is associated with rising unemployment. The minimum wage coefficients remain stable, positive, and statistically significant even in downturns, suggesting that their effect is not merely a reflection of cyclical conditions.

The analysis of the interaction term reveals that its coefficient is positive and statistically significant in the fixed effects specifications (Columns 5 and 6), which does not support the hypothesis that adverse effects are driven by policies enacted at cyclical peaks. If that were the case, we would expect a negative interaction term, reflecting stronger effects when GDP growth is low or negative. This finding, combined with the consistent signs of the minimum wage variables in the GMM models (Columns 7 and 8), further mitigates concerns about cyclical endogeneity Overall, the robustness of our core findings suggests that minimum wage increases exert a modest adverse effect on unemployment that persists across different phases of the business cycle.

6.2. The estimated own wage elasticity: Comparison with existing evidence

To enhance comparability with the broader literature on minimum wage effects, we calculate own wage elasticity (OWEs), which measure the percentage change in employment relative to the percentage change in the minimum wage based on our estimated coefficients[5]. Our estimates, derived from both the fixed effects and the system GMM specifications, range from −0.069 to −0.088. This indicates that a 10% increase in the minimum wage is associated with a 0.69% to 0.88% reduction in the employment rate, reflecting a small negative effect of minimum wages on employment.

These findings are consistent with the broader empirical literature, particularly the meta-analysis by Dube and Zipperer (2024), who find a median OWE of approximately −0.13. The modest magnitude of our estimated OWEs suggests that while minimum wage increases are associated with a reduction in employment, the effect is relatively small. This supports our primary conclusion that the economic trade-off of higher minimum wages (i.e., a small, adverse effect on unemployment) may be outweighed by the social benefits of such policies.

6.3. The minimum wage and labor cost channel

A possible channel through which minimum wages may negatively affect both unemployment and employment is by exerting upward pressure on other wages, thereby increasing overall labor costs. This aligns with the neoclassical mechanism, where higher minimum wages raise the total labor costs, which in turn reduces labor demand.

To investigate this channel, we conducted two supplementary analyses. First, we examined the association between changes in the level of the minimum wage and the annual growth rates of nominal labor costs across 21 EU economies. To visualize these relationships, we created a series of scatter

[5] The calculation is based on this formula: $\text{OWE} = \frac{\%\,change\ in\ employment}{\%\,change\ in\ the\ min.\ wage!} = \beta\ x\ \frac{\overline{W}}{\overline{E}}$.

plots for different economic sectors (mining and quarrying, manufacturing, construction, and services), illustrating how minimum wage dynamics relate to labor cost trends (Figure A.1). Second, we performed Granger causality tests to assess whether the previous year's level of minimum wage Granger-cause (helps predict) the current growth rates of nominal total labor costs across these four economic sectors.

The scatter plots visually indicate a positive association between the annual growth rate of the minimum wage and labor costs across all four economic sectors, suggesting that as minimum wages rise, labor costs tend to increase as well. This visual association is further supported by the results of Granger causality tests[6]. The findings provide statistical evidence that the previous year's minimum wage growth has predictive power over the current year's labor cost growth in most of the sectors analyzed (Table A.6).

These findings provide preliminary indications of an associative channel between minimum wage growth and broader labor cost increases. However, it must be noted that this analysis is indicative rather than conclusive. A full examination of wage distribution effects and the establishment of robust causal inference were beyond the scope of this paper and remain an avenue for future research.

7. Discussion and concluding remarks

This study provides empirical evidence on the relationship between minimum wage policies and unemployment dynamics across 21 EU member states over the period of 2000–2023. Using a combination of fixed effects and dynamic panel estimators, we find that increases in the minimum wage are associated with a statistically significant, yet economically modest, rise in unemployment. This effect is more pronounced among vulnerable groups, such as youth and low-skilled workers, suggesting that while minimum wage policies may serve broader social goals, they are not without labor market trade-offs.

Importantly, our findings remain consistent across a range of model specifications and robustness checks, including controls for macroeconomic shocks, structural adjustment programs, political and cyclical endogeneity, as well as the influence of potential outliers. The modest magnitude of the estimated effects, both in terms of unemployment increases and employment reductions, suggests that fears of widespread labor market disruptions and job losses may be overstated.

Nevertheless, the results also highlight the heterogeneity of impacts across demographic groups and economic conditions. Although the effects remain modest, the persistence of unemployment and the sensitivity of youth and low-skilled employment to wage floors underscore the need for complementary policies, such as targeted training programs, active labor market interventions, and region-specific wage setting mechanisms.

Given the ongoing debate in the literature and the mixed empirical evidence, the employment effects of minimum wage policies remain an open question. Future research could benefit from more granular data, including sectoral and regional breakdowns, as well as from exploring the interaction between minimum wage policies and other institutional factors such as collective bargaining coverage, tax-benefit systems, and automation trends. Such efforts would help policymakers design more nuanced and effective labor market interventions that balance equity and efficiency.

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[6] Granger causality tests require the variables to be stationary. Unit root tests were performed, and all variables were confirmed to be stationary (table A.5).

Additionally, we acknowledge the absence of direct evidence on wage distribution effects as a limitation of our study. While our supplementary analysis suggests a link between minimum wage increases and rising labor costs, more formal econometric evidence is needed to establish a robust causal relationship. Future research should aim to directly assess the impact of minimum wage policies on wage distributions across the workforce, ideally using micro-level data and longitudinal designs to capture dynamic effects over time.

Use of AI tools declaration

The authors declare they have not used Artificial Intelligence (AI) tools in the creation of this article.

Author contributions

Conceptualization: AP, AG, Methodology: AP, AG, Data Curation: AP, AG, Formal Analysis: AP, Writing – Original Draft: AP, AG, Writing – Review & Editing: AP, AG.

Conflict of interest

All authors declare no conflicts of interest in this paper.

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