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Debt Thresholds and Unemployment Nexus: A Study on Fiscal–Monetary Policy Interactions Across the EU Member States

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Abstract

This study examines the regime-dependent threshold between fiscal and monetary policy interactions across the EU-27 states, utilizing quarterly data from 2000 to 2025. A fixed-effects panel threshold regression model has been adopted in this study, using endogenously determined debt thresholds, to assess how budget, debt, money supply, inflation, and fluctuations in interest rates interact under different debt regimes. This analysis also incorporates shock dummy variables following mild recessions and inflationary pressures, the global financial crisis, the sovereign debt crisis, the COVID-19 pandemic, and recent energy price and inflationary shocks. Consequently, three major findings emerge: firstly, fiscal deficits increase unemployment across both regimes, but their positive contribution is significantly reduced by 81% in high-debt regimes. Therefore, conventional Ricardian equivalence has been supported throughout this study in terms of precautionary savings and crowding-out impacts, which further contribute to intensifying with alternative debt regimes. Secondly, monetary variables, in this paper, have demonstrated limited direct effects on unemployment mitigation that highlight the transmission mechanisms under high-debt regimes. Thirdly, the effectiveness of crisis response critically depends on existing fiscal spaces, while the debt regime is interconnected with labor market outcomes. The main findings of the study provide empirical support for the Maastricht debt criterion of 60% as a structural threshold, which is a benchmark for a fundamental shift in the policy transmission mechanism. This study has identified rules and regulations for uniform fiscal consolidation as insufficient; rather, state-contingent governance frameworks have been highly recommended for managing asymmetrical fiscal–monetary policy interactions across different debt regimes. Furthermore, it contributes to the reformation of the more impactful fiscal and monetary policy interaction rule under a monetary union.

Keywords: fiscal; monetary; government debt; unemployment; debt thresholds

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1. Introduction

Unemployment imposes one of the major macroeconomic challenges across the European Union (EU) following the era of different global financial disruptions. During the last two decades, the EU economies had undergone a bunch of economic shocks; 2001Q1–2002Q4 started with mild recession and inflationary pressure, 2008Q4–2009Q4

global financial crisis, 2011Q1–2012Q4 sovereign debt crisis, COVID-19 pandemic 2020Q1–2021Q4 followed by global energy and inflationary shock 2022Q1–2022Q4; therefore, events have generated significant heterogeneity in responding to different policy interventions (Ali et al., 2022; Ffrench-Davis, 2010; Hein & Truger, 2007; Hijzen & Martin, 2013; Sun et al., 2024). These economic shocks have exposed several vulnerabilities across the EU labor market and highlighted the requirement for effective fiscal and monetary policy interventions. Furthermore, an empirical puzzle has been revealed that all the adopted fiscal and monetary policies do not refer to a uniform level of improvement in unemployment conditions across the EU countries; state-dependence and nonlinear policy transmission have a significant impact on determining unemployment outcomes, especially when confronted with higher levels of public debt (Feldmann, 2009; Jackman et al., 1990).

Following the Economic and Monetary Union (EMU) and Maastricht criteria, all EU member states maintain convergence rules aimed at maintaining macroeconomic stability. But with the evidence of the last 25 years, the EU member states have been revealed with remarkable variation in these criteria, exceeding 100% of their GDP (Eurostat, 2025; Statista, 2025; Trading Economics, 2025b).

Different Traditional macroeconomic models represent linear relationships among policy variables (such as fiscal deficits, interest rates, inflation, and money supply) and unemployment, regardless of the economic context (Egilsson, 2020; Orphanides & Solow, 1990; Parkin, 1998). However, in an increasing amount of literature, it is evident that these effects are highly regime-dependent (such as debt levels, financial distortions, or trade openness).

The regime-dependent policy foundation has been extracted from a diversified theoretical background as well (Dosi et al., 2018; Oderinde et al., 2024). Keynesian theory stated that fiscal expansion may stimulate aggregate demand, which results in unemployment mitigation conditionally during recession having large output gaps. But a high debt environment may impose constraints on its effectiveness through enhancing precautionary savings at households, crowding out private investment, or probable expectations of fiscal consolidation in the future (Arestis, 2015; Blinder, 2008; Brown-Collier & Collier, 1995; Fletcher, 1987).

According to the Ricardian equivalence, forward-looking agents initiate higher levels of increase in future taxes to cope with the debt burden, thereby cushioning the stimulating impact of deficit spending. Alongside, monetary transmission mechanisms through interest rate, credit supply, and expectations of the inflationary pressure induce complexities when fiscal spaces become narrow (Roehn, 2010; Sardoni, 2021).

Following the EU context, cross-sectional interdependence is highly noted across the member states. While the entire economic environment is integrated with one another through trade, finance, and common monetary policy mechanisms, any kind of macroeconomic problems and policy interventions are also spilling over from one to another. Despite the huge amount of existing fiscal–monetary policy interactions and unemployment-oriented literature, how these policy interactions respond to diversified debt regimes across the EU countries is understudied. When some literature focuses on the threshold effects of economic growth or investment, on the other hand, few studies have analyzed unemployment outcomes following different regime-generated frameworks (such as debt thresholds, cross-sectional dependence, and dynamic policy lags) (Arnholtz & Leschke, 2023; Oderinde et al., 2024).

An increased level of government debt intensified complexities for long-term growth and maintenance of sustainable fiscal space, and, therefore, initiated the necessity for the adoption of austerity measures for many countries. Following existing theory and empirical evidence, where most of the literature focuses on the debt-to-GDP threshold, it is evident that high debt has a negative correlation with GDP growth, although, in this regard, institutional capacity controlled by democracy acts as the key threshold. Countries having

weak institutions face a reduction in overall growth due to excessive government debt, while it represents growth neutrality under strong democracies (Kourtellos et al., 2013). The intensive increase in government debt to GDP during the COVID-19 pandemic further renewed the debate on the long-run growth impacts. Ricardian Equivalence indicates growth-neutral impacts of debt, while, on the other hand, potential negative and nonlinear impacts by debt thresholds are identified through alternative theories as well as existing empirical studies (Chen et al., 2024).

Accompanied by fiscal and monetary indicators used in this study, institutional capacities, particularly in terms of economic freedom, are among the critical but structural determinants of unemployment dynamics across EU countries. Feldmann (2009) stated that unemployment persistence has been significantly affected by the labor-market regulations across the OECD countries, where more structural and regulatory frameworks correlated with expansionary structural unemployment.

The Heritage Foundation has the Economic Freedom Index, while the Fraser Institute represents the Economic Freedom World Index. In both cases, they concentrate on institutional capacities that consist of regulatory quality controls, freedom, and flexibility in the labor market, all of which have significant contributions to shaping the nature of fiscal and monetary policy transmission to the labor market (Compton et al., 2011; J. D. Gwartney et al., 2006).

Despite having significant harmonization efforts across the EU level, economic freedom indices represent substantial heterogeneity in institutional capacity and their effective performance across the EU levels. This significant consideration on labor-market regulation and flexibility has been underexplored by the conventional macroeconomic variables (Bennett & Nikolaev, 2017). The absence of the Economic Freedom Index in fiscal- monetary interaction studies imposes potential gaps since institutional quality is assessed by the credibility of enhancing fiscal spaces, as well as monetary policy transmission outcomes (Bjørnskov & Foss, 2016; De Haan et al., 2006).

Focusing on the above-mentioned theoretical and practical aspects, nonlinear fiscal and monetary policy effects on unemployment mitigation across 27 EU member states following quarterly data of 2000–2025; this comprehensive data frame has encompassed pre-crisis, multiple crisis periods, and post-crisis recoveries during this period. This diversified robust variation has been represented in determining the effects of (debt) regime-dependent policy interactions. A panel threshold regression (PTR) model has been used in this study with fixed effects representing debt thresholds under endogenous estimation, where unobserved country-specific heterogeneity and common time effects have been controlled. Comprehensive unit root tests, cross-sectional dependency, diagnostic, as well as multiple robustness checks following lag structures, and Driscoll-Kraay robust standard errors check have been incorporated in this study.

This introduction, Section 1, has presented the main contribution of the study, along with providing potential keynotes on macroeconomic challenges imposed by unemployment across the EU-27 countries and their counteractions with multiple economic shocks. These events highlight the heterogeneous nature of fiscal and monetary policy interactions under a diversified debt regime. This study has been designed to assess how individual fiscal and monetary policies and their interactions impact unemployment with a heterogeneous nature (both binary in model specification and continuous regime specifications for robustness check), following different debt thresholds of 50%, 60%, and 70%. Followed by the adjustment of cross-sectional dependence and dynamic policy lags 1 and 2.

The remainder of this paper will be proceeding as follows; Section 2 represented the reviews of the existing literatures based on the combined impact of fiscal and monetary policies on unemployment dynamics; Section 3 describes the methods used in this study for data collection, selection of the variables, baseline model estimation and validation

followed by several robustness checks; Section 4 presents empirical results and findings and Section 5 represents discussion followed by concluding remarks with required future policy recommendations in Section 6.

2. Literature Review

Following the fiscal, monetary, and labor markets' dynamic interactions documented in several European Panel studies, delayed and persistent impacts of fiscal instruments on unemployment mitigation initiatives have been reported. These issues have remained inherently sluggish and unfold over longer periods, which has been consistent with the theoretical models concerning price and wage rigidities representing a gradual implication than contemporary policy transmission (Akca & Bozatli, 2020; Cuestas & Monfort, 2023).

The relationship between fiscal and monetary policies and unemployment represents a significant amount of heterogeneity while considering the level of total debt accumulation. In this regard, Keynesian theory posits a universal explanation regarding the capability of expansionary fiscal policies in stimulating aggregate demand, therefore, reducing unemployment in response to economic shock, particularly when a large output gap has existed. However, the executive pattern of fiscal multipliers varies considerably across the states. Auerbach and Gorodnichenko (2012) demonstrated that the larger use of fiscal multipliers during the time of recessions rather than expansions clearly suggest effectiveness of state dependency. Following the post 2008 global financial crisis, in the European context, asymmetric effects have been revealed in this regard, where high-debt countries are expected to experience more job losses under the implementation of the same austerity measures (Alesina et al., 2015). This heterogeneity represents the dependence of fiscal transmission mechanisms on their initial debt accumulation as well as institutional capabilities to handle those, rather than their uniform operating pattern across all the EU economies (Ali et al., 2022; Ffrench-Davis, 2010; Hein & Truger, 2007; Hijzen & Martin, 2013; Sun et al., 2024). Therefore, debt thresholds have gained prominence in the literature as a determinant of fiscal effectiveness (Égert, 2015; Herndon et al., 2014; Reinhart & Rogoff, 2010).

Baum et al. (2013), in their study, have represented several debt thresholds of 67% and 95% across the EU area, which reflected the problematic existence of debt dynamics. Checherita-Westphal and Rother (2012) evidenced the Maastricht 60% criterion for economic growth effects but failed to determine a clear threshold in the usage of fiscal multipliers, particularly in the OECD countries, through which context-dependency was determined (Chudik et al., 2017).

This is a continuous fiscal transmission mechanism where higher debt levels impose constraints in terms of crowding out private investment. This crowding out effects are more influenced by the expectations of the future fiscal consolidation following the Ricardian equivalence mechanism (Roehn, 2010; Sardoni, 2021). This is a common precautionary behaviour that generates sovereign risk of credit constraints (Hodula & Melecký, 2020). It limits the credibility of the monetary union in shock absorption, particularly when exchange rate adjustment is temporarily restricted in response to financial distortion (Corsetti et al., 2013). These channels are still limited for the EU labor markets (Égert, 2015).

Monetary policy generates its influence on unemployment mitigation through the channels of interest rates, which generate structures for borrowing costs, investment, and aggregate demand. Following the literature, it is found that government debt and interest rates are interconnected through time-varying transmission mechanisms in terms of their crucial impact on unemployment dynamics. Empirical evidences highlight the long-run implications of interest rates on debt and deficits, although their implications become limited over time; therefore, focus on regime-dependent fiscal–monetary mechanisms (Wang & Rettenmaier, 2008). Higher government budget deficits and debt to GDP have

significant contributions to further enhancing risk on borrowing costs, which has been confirmed by both earlier and recent findings (Cebula, 2025). Finally, it has been concluded according to the existed literatures that high-debt regimes potentially contribute to weakening the policy transmission for reducing the effectiveness of the unemployment mitigating tools under shock conditions.

From the quarter century 2000–2025, the European Union has undergone a sequential economic shock following mild recession and labor market constraint in 2001–2002, global financial crisis 2008, followed by the banking and credit crunch shock, disruption in international trade, and Eurozone sovereign debt crisis from 2008Q4 to 2012Q4. Between 2020Q1 and 2022Q4, the COVID-19 pandemic shock (2020Q1–2021Q4), and therefore, global energy and inflationary (cost-push) shock (2022Q1–2022Q4), the ECB's zero lower bound interest rate (ZLB) constraints several times interrupted conventional transmission, rather than boost up different unconventional tools of quantitative easing, negative interest rates, and different employment intensive schemes like wage subsidies, unemployment benefits, skill development programs (Albertini & Poirier, 2015, Ali et al., 2022; Ffrench-Davis, 2010; Hein & Truger, 2007; Hijzen & Martin, 2013; Sun et al., 2024). Wu and Xia (2016) evaluate "shadow rates" as a form of continuous effectiveness, whereas, on the other hand, some other literatures highlight limited influences in financially imbalanced countries as well as countries with fiscally constrained. These prolonged ZLB, most often, reflected conventional rate adjustments as inappropriate. This contradiction between monetary and fiscal stances is still critical as well as understudied. In a high-debt regime, monetary stimulus measures are found to be muted in the presence of the debt sustainability issues, while fiscal multipliers tend to be increased, followed by ZLB constraints, representing the complementary nature of fiscal and monetary policy interaction (Égert, 2015). Therefore, it represents heterogeneity across debt regimes in response to unemployment mitigation despite having limited evidence across the EU countries (Brunnermeier et al., 2016; Corsetti et al., 2013).

The traditional Phillips curve relationship between inflation and unemployment has exhibited instability over time and across countries, with low unemployment increasingly generating muted inflation, challenging traditional formulations (Galí, 2011). The EU-27 countries represent different wage setting, market flexibilities, as well as different integrated global supply chains, which can differentiate the inflationary pressure and unemployment dynamics across the countries. Expectation of Well-anchored inflation can contribute to steepening the short-run Phillips curve, where lower unemployment is possible without triggering inflationary pressure, although these types of effects seem to be weakened. Moreover, integrated economic characteristics (trade linkages, integrated market mechanisms, common monetary policy adoption) all over the EU countries represent substantial interdependence (spill over) among themselves. Consequently, any diversified natural or man-made initiatives can impose unrest across the border as well (De Grauwe, 2016). As it is evident, the European sovereign debt crisis can be considered where debt pressure on the peripheral countries can spread drastically through the banking systems, generated their contractionary impact through enhancing unemployment across the Union (Shambaugh, 2012), followed by the global financial crisis (2008Q4–2009Q4), the COVID-19 pandemic (2020Q1–2021Q4), and the inflationary pressure and energy crisis of 2022Q1–2022Q4 (Auntu & Pilinkienė, 2026). All the member states have been affected simultaneously, although with different intensity due to their own national economic frameworks and fiscal spaces, followed by monetary capacities as well. But their shared exposure in generating unemployment across the neighbouring countries can no longer be put in isolation (Chudik et al., 2017).

In response, significant studies have shown that the impact of government budget deficits on the overall national economy can be explained by low-debt and high-debt

regimes (Checherita-Westphal & Rother, 2012; Herndon et al., 2014), while, on the other hand, the monetary transmission mechanism is controlled by the advancement of the designated financial sector. These regime-dependent characteristics impose challenges on traditional linear models.

Although extensive literature existed on fiscal and monetary interactions and unemployment. However, significant gaps are yet to be addressed in terms of their cross-sectional dependence across debt regimes in the EU over extended time periods, despite being declared as the clear tools for assessing the policy transmission mechanism in the monetary unions. But it is still quite underexplored due to validity concerns caused by existing inference. Some countries have selected the debt-based threshold effects on either growth or investment, keeping the labor market outcome in isolation. Few studies systematically explain the integration of fiscal and monetary policy dynamics (complements or substitutes) under different regimes (such as debt threshold, cross-sectional dependency, or policy lags), but it is still understudied. This paper has taken initiatives to address these gaps through implementing panel threshold regression with fixed effects model to assess their fiscal and monetary policy interactions on unemployment under the debt regime across the 27 EU countries following the time frame of 2000–2025. However, in this study, three significant hypotheses have been constructed, which will be further tested in Section 4 and discussed in Section 5.

H1. *Interaction between debt threshold and fiscal–labor market nonlinearity.*

The interaction between expansionary fiscal measures and unemployment is regime dependent. Where the crossing of 60% debt-to-GDP threshold is considered a structural break, it indicates that expansionary budget deficits enhance unemployment in both of the debt regimes; therefore, their adverse effects weaken once government debt crosses the baseline threshold levels.

H2. *Impaired Monetary Transmission under High Public Debt.*

The impact of monetary policy on unemployment mitigation weakens following the increase in government debt to GDP level, and therefore represents an impaired monetary transmission mechanism under high-debt regimes.

H3. *Crisis Amplification of Debt-Regime Asymmetries.*

Regime-dependent asymmetries have been amplified by economic crisis episodes in the labor market, where high-debt regimes experience stronger adverse effects than low-debt economies due to limited fiscal space and counter-cyclical capacity.

Debt thresholds have been estimated endogenously rather than adopting their predetermined values. Robustness of the test has been checked at 50%, 60%, and 70% of threshold specification (using binary model specifications and continuous debt values, associated with first and second-generation unit root tests and Driscoll-Kraay robust standard errors, with a view to determining cross-sectional dependence. Further lagged specifications (1 and 2) and shock dummy variables have been incorporated to assess the dynamic nature of fiscal and monetary variables and their crisis interactions in Section 3.

3. Methodology

3.1. Research Design

This study has been incorporated into quarterly panel data comprised of 27 European Union (EU) countries across 2000–2025, which enables us to examine the policy-interaction

effects across different major shocks under different debt regimes in a consistent panel. The sample areas used in these countries are as follows: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, and Sweden, which encompass both Euro and non-Eurozone countries. These EU countries, although they have been operated under common institutional maintenance, have diversity in their monetary transmission procedures. It enhances the probability to analyze cross-country heterogeneity in fiscal spaces, diversified labor market structures, as well as their policy-transmission mechanism, while being confronted with constant EU-level rules and regulations.

All the variables mentioned in Table 1 are measured quarterly for the 27 EU countries (Both the Euro and non-Euro zone countries) from 2000Q1 to 2025Q4. Most of the data is extracted from Eurostat (2025) and Trading Economics (2025a, 2025b) databases. Missing observations have been interpolated using linear interpolation conducted in Eviews software, and the rest of the empirical calculations have been conducted by R 4.3.2.

Table 1. Operational definition of the variables.

Variables	Symbols	Definition	Justification of the Selected Variables from Existing Literatures
Unemployment rate (%)	ump_{it}	A share of labor aged 15–74 who are actively searching for jobs and available to join the jobs in two weeks.	(Arestis, 2015; Jackman et al., 1990; Parkin, 1998)
Interest rate (%)	int_{it}	The cost needs to be paid when borrowing currency from eurozone commercial banks and for non-eurozone EU countries using their national bank policy rates.	(Abadi et al., 2023; Adarov, 2021)
Inflation rate (%)	$infl_{it}$	Consumer Price Index (CPI) is counted as a growth rate of the index in each of the given periods.	(Egilsson, 2020; Orphanides & Solow, 1990; Parkin, 1998)
Govt budget deficit (%)	def_{it}	Net borrowing (negative) or lending (positive) of the government as a percentage of GDP.	(Fedeli et al., 2015; Mwigeka, 2025)
Govt debt to GDP (%)	$debt_{it}$	Government gross debt (currency, deposits, debt securities, and loans) as a percentage of GDP.	(Dornbusch, 1988; Heer & Schubert, 2012; Ogonna et al., 2016)
Money supply m3 (% of GDP)	$m3_{it}$	Total liquids existed in an economy in terms of cash, deposits, or short-term market investment, calculated as % of GDP	(NaiMoğlu, 2023; Nkamba et al., 2023; Shiblee, 2009)
Shock dummy (binary indicator 0/1)	$shock_{it}$	2001Q1–2002Q4 (mild recession), 2008Q4–2012Q4 (financial and sovereign shock), 2020Q1–2021Q4 (COVID-19), and 2022Q1–2022Q4 (energy and inflationary shock) as 1, otherwise 0	(De Serres & Murtin, 2014; Eamets et al., 2003; Kornstad et al., 2013)
Economic Freedom Index	efi_{it}	Demographic system of the government, Legal System, Property Rights, Sound Money supply, Freedom of international Trade and commerce	(J. Gwartney et al., 2023; Fraser Institute, 2024)
Regime (binary indicator 0/1, continuous both)	$regime_{it}$	Government debt-to-GDP ratio exceeds 60%, specified as 1, otherwise 0.	(Arnholtz & Leschke, 2023; Feldmann, 2013; Oderinde et al., 2024)

3.2. Diagnostic Tests

3.2.1. Cross-Sectional Dependency Test

With a view to assessing the presence of cross-sectional dependence across the EU-27 states, Pesaran (2021) developed a cross-sectional dependence (CD) test, where for each variable, i denotes the country and t denotes time.

$$y_{it} \in \left(ump_{it},\ debt_{it}, def_{it}, int_{it}, infl_{it}, m3_{it}\right) \tag{1}$$

where *i* denote country and t for time.

For this Pesaran CD test, if i and j are used as two countries used in this study, then equations come as the two states of the study, then equations come as follows-

$$\widehat{\rho_{ij}} = \frac{\sum_{t=1}^{T} \widehat{\varepsilon_{it}}\widehat{\varepsilon_{jt}}}{\sqrt{\left(\sum_{t=1}^{T} \widehat{\varepsilon_{it}^2}\right)\left(\sum_{t=1}^{T} \widehat{\varepsilon_{jt}^2}\right)}} \tag{2}$$

$$CD^{y} = \sqrt{\frac{2T}{N(N-1)}} \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \widehat{\rho_{ij}^{y}} \tag{3}$$

where $\hat{\rho}_{ij}^{(y)}$ is the sample correlation coefficient inside residuals of countries *i* and j, N is denoted number of countries.

$H_0 = \hat{\rho}_{ij}^{(y)} = 0$ where all $i \neq j$ represents not having any cross-sectional dependence

$H_1 = \hat{\rho}_{ij}^{(y)} \neq 0$ where some $i \neq j$; acknowledges cross-sectional dependence

3.2.2. CIPS Test

Pesaran CD test plays a crucial role in unit root test examination since its existence may bias the results of first-generation unit root tests (LLC and IPS). Therefore, it enhances the necessity of the second-generation CIPS test (appropriate for EU panel data), which has been conducted as follows

$$\Delta y_{it} = \alpha_i^{(y)} + \beta_i^{(y)} y_{i,t-1} + \phi_{1i}^{(y)} \overline{y}_{t-1} + \phi_{2i}^{(y)} \Delta \overline{y}_t + \sum_{k=1}^{p_i^{(y)}} \gamma_{ik}^{(y)} \Delta y_{i,t-k} + \varepsilon_{it}^{(y)} \tag{4}$$

where y_{it} is the dependent variable of this study is presented in Equation (1), $\overline{y}_t$ denotes the cross-sectional average for all the countries at *t*, $\alpha_i^{(y)}$, country-specific intercept, $\beta_i^{(y)}$ is the coefficient tested for a unit root, while $\phi_{1i}^{(y)}$ and $\phi_{2i}^{(y)}$ is captured for analyzing the common shocks, $p_i^{(y)}$ represents the lag length while $\gamma_{ik}^{(y)}$ are acting as coefficients on lagged differences, and $\varepsilon_{it}^{(y)}$ denotes the error term. Following Equation (3), CIPS statistics are calculated as CADF t-statistics.

$$IPS^{(y)} = \frac{1}{N} \sum_{i=1}^{N} t_{\beta_i}^{CADF,y} \tag{5}$$

Here, $H_0 = \beta_i^{(y)} = 0$ for all.

$H_1 = \beta_i^{(y)} < 0$ allows stationarity for at least some countries.

3.2.3. Unit Root Test

This unit root test has been conducted in this paper to check the stationarity of the variables, which is a mandatory prerequisite for the estimation of any panel or non-linear model. Otherwise, it may generate biased, inconsistent, or spurious regression results. In this study, quarterly panel data have been included for 27 EU countries (including both Eurozone and non-Eurozone countries, the UK excluded); time-series unit-root tests will be

insufficient. Therefore, using both first-generation tests (for assuming cross-sectional independence) and second-generation tests (allowing interdependence) establishes a stronger statistical foundation.

The Levin–Lin–Chu (LLC) unit root test has been represented assuming the existence of cross-sectional independence as well as the presence of homogeneous autoregressive parameters.

$$\Delta y_{it} = \alpha_i + \beta y_{I,t-1} + \sum_{k=1}^{P} \delta_k \Delta y_{I,t-k} + \in_{it} \quad (6)$$

H_0: $\beta = 0$; The null hypothesis confirms a unit root, H_1: $\beta < 0$ while the alternative hypothesis implies stationarity once fixed effects are.

Following Equation (6), the IPS unit root test has been conducted to get a more reliable, flexible, and robust stationarity assessment result when it is confronted with a heterogeneous panel like the EU.

$$\Delta y_{it} = \alpha_i^{(y)} + \beta_i^{(y)} y_{I,t-1} + \sum_{k=1}^{p_i^{(y)}} \delta_{ik}^{(y)} \Delta y_{I,t-k} + \in_{it}^{(y)} \quad (7)$$

$$IPS^{(y)} = \frac{1}{N} \sum_{i=1}^{N} t_{\beta_i}^{ADF,y} \quad (8)$$

where $H_0: |\beta_i^{(y)} = 0 \forall i$ represents all the cross-sectional panel used in this study has unit roots, while on the other hand, $H_1: |\beta_i^{(y)} < 0$ confirms stationarity in at least one country in the panel. In Equation (8), two additional symbols have been used, such as $t_{\beta_i}^{ADF,y}$ which represent the ADF t-statistic for $\beta_i^{(y)}$, $IPS^{(y)}$ denotes as Im–Pesaran–Shin panel unit root statistic.

3.3. Model Specifications

This approach can be considered as well fitted following three key factors- existence of the cross-sectional dependency across the EU economy, as figured out by the Pesaran CD test, where policy impacts are less likely to be linear across the countries; non-stationary variables are found with heterogeneity, where it is assumed that fiscal and monetary interactions may impose diversified implications on unemployment mitigation under different debt regimes; finally, when unobserved country-specific heterogeneity needs to be controlled. The FE-PTR framework, therefore, represents nonlinear threshold effects associated with cross-sectional interdependence, making it appropriate for analyzing unemployment outcomes in response to the interaction of fiscal and monetary policies in an integrated monetary union.

At first baseline fixed effect panel regression model has been generated using the selected variable for this paper

$$ump_{it} = \beta_0 + \beta_1 def_{it} + \beta_2 regime_{it} + \beta_3 int_{it} + \beta_4 infl_{it} + \beta_5 m3_{it} + \beta_6 debt_{it} + \beta_7 efi_{it} + \mu_i + \lambda_t + \epsilon_{it} \quad (9)$$

Therefore, with a view to assessing regime-dependent policy interactions, the FE-PTR framework has been developed (Hansen, 1999). The model mainly works with heterogeneous coefficients across different debt regimes based on an endogenous threshold. γ; where (L) and (H) represents low-debt and high-debt regimes.

$$\gamma = \arg min_{\gamma} \sum_{t=1}^{N} \sum_{t=1}^{T} \left[ump_{it} - \hat{\mu}_i - \hat{\beta}^{(L)} X_{it} 1debt_{it} \leq \gamma - \hat{\beta}^{(H)} X_{it} 1debt_{it} > \gamma - \hat{\lambda}_t \right]^2; \quad (10)$$

where X_{it} represents the vector of explanatory variables and $1\{\cdot\}$ denotes an indicator function. Panel threshold regression results for unemployment across debt-based regimes (50%, 60%, 70% thresholds) have been conducted as an alternative specification.

$$\begin{aligned}\text{ump}_{\text{it}} = \beta_0 + \beta_1\text{def}_{\text{it}} + \beta_2\text{regime50}_{\text{it}} + \beta_3\text{int}_{\text{it}} + \beta_4\text{infl}_{\text{it}} + \beta_5\text{m3}_{\text{it}} + \beta_6\text{debt}_{\text{it}} + \beta_7\text{efi}_{it} + \beta_8(\text{def}_{\text{it}} \times \\ \text{regime50}_{\text{it}}) + \beta_9(\text{regime50}_{\text{it}} \times \text{int}_{\text{it}}) + \beta_{10}(\text{regime50}_{\text{it}} \times \text{infl}_{\text{it}}) + \beta_{11}(\text{regime50}_{\text{it}} \times \text{m3}_{\text{it}}) + \\ \beta_{12}(\text{regime50}_{\text{it}} \times \text{debt}_{\text{it}}) + \beta_{13}(\text{regime50}_{\text{it}} \times \text{efi}_{\text{it}}) + \mu_{\text{i}} + \lambda_{\text{t}} + \epsilon_{\text{it}}\end{aligned} \tag{11}$$

$$\begin{aligned}\text{ump}_{\text{it}} = \beta_0 + \beta_1\text{def}_{\text{it}} + \beta_2\text{regime60}_{\text{it}} + \beta_3\text{int}_{\text{it}} + \beta_4\text{infl}_{\text{it}} + \beta_5\text{m3}_{\text{it}} + \beta_6\text{debt}_{\text{it}} + \beta_7\text{efi}_{it} + \\ \beta_8(\text{def}_{\text{it}} \times \text{regime60}_{\text{it}}) + \beta_9(\text{regime60}_{\text{it}} \times \text{int}_{\text{it}}) + \beta_{10}(\text{regime60}_{\text{it}} \times \text{infl}_{\text{it}}) + \beta_{11}(\text{regime60}_{\text{it}} \times \text{m3}_{\text{it}}) + \\ \beta_{12}(\text{regime60}_{\text{it}} \times \text{debt}_{\text{it}}) + \beta_{13}(\text{regime60}_{\text{it}} \times efi_{\text{it}}) + \mu_{\text{i}} + \lambda_{\text{t}} + \epsilon_{\text{it}}\end{aligned} \tag{12}$$

$$\begin{aligned}\text{ump}_{\text{it}} = \beta_0 + \beta_1\text{def}_{\text{it}} + \beta_2\text{regime70}_{\text{it}} + \beta_3\text{int}_{\text{it}} + \beta_4\text{infl}_{\text{it}} + \beta_5\text{m3}_{\text{it}} + \beta_6\text{debt}_{\text{it}} + \beta_7\text{efi}_{it} + \\ \beta_8(\text{def}_{\text{it}} \times \text{regime70}_{\text{it}}) + \beta_9(\text{regime70}_{\text{it}} \times \text{int}_{\text{it}}) + \beta_{10}(\text{regime70}_{\text{it}} \times \text{infl}_{\text{it}}) + \beta_{11}(\text{regime70}_{\text{it}} \times \text{m3}_{\text{it}}) + \\ \beta_{12}(\text{regime70}_{\text{it}} \times \text{debt}_{\text{it}}) + \beta_{13}(\text{regime70}_{\text{it}} \times efi_{\text{it}}) + \mu_{\text{i}} + \lambda_{\text{t}} + \epsilon_{\text{it}}\end{aligned} \tag{13}$$

$regime_{it} = 1\{debt_{it} > \gamma\}$ has been used in this study as a binary indicator equivalent to one, baseline debt limit crossing the threshold (60), where $\beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6, \beta_7$ capture fiscal and monetary policy impacts in the low-debt induced regime when $\beta_8, \beta_9, \beta_{10}, \beta_{11}, \beta_{12}$, and$\beta_{13}$ determine their interactions with one another under a high debt regime.

3.4. Robustness Check

3.4.1. Continuous Regime Specifications and Their Interaction Terms

While in Section 3.2 fixed effect panel threshold model has been developed using binary regime specifications, which have a significant probability to impose discontinuities (arbitrary), while a continuous regime variable tends to represent diversified policy effects smoothly across diversified debt distribution.

$$\text{regime}_{\text{c,it}} = \frac{debt_{it} - \min(debt)}{\max(debt) - \min(debt)} \tag{14}$$

where min(debt) and max($debt$) represents observations of minimum and maximum debt values in the sample. In this transformation phase, for the least-indebted values, $\text{regime}_{\text{c,it}} = 0$ while for the most-indebted values, $\text{regime}_{\text{c,it}} = 1$; the rest of the intermediate values denote relative positions in the distribution of debt. With intermediate values representing relative positions in debt distribution. Therefore, these continuous regime specifications are constructed as follows:

$$\text{ump}_{it} = \beta_0 + \beta_1 X_{it} + \beta_2(X_{it} \times \text{regime}_{it}) + \mu_i + \lambda_t + \epsilon_{it} \tag{15}$$

These interaction terms ($X_{it} \times \text{regime}_{it}$) represents the diversity of each of the policy variables with continuous values of debt-level. Here, the marginal impact of the policy variable X on unemployment is represented:

$$\frac{\partial ump_{it}}{\partial x_{it}} = \beta_1^x + \beta_2^x \tag{16}$$

where the marginal impact of regime_{it} transform β_1^x at regime_{it} to $\beta_1^x + \beta_2^x$ at $\text{regime}_{\text{c,it}} = 1$. If the interaction coefficient β_2^x is statistically significant, it represents the systematic diversity of policy effects with debt levels, and their signs indicate whether effectiveness increases or decreases with indebtedness.

The continuous regime specification contributes to capturing the monetary transmission mechanism across the highly indebted economies generated from higher levels of sovereign risks, fragmentation of economic activities, and a limited amount of fiscal space, for the progression from policy rates to economic activities. This comparison between the threshold and continuous models further fills gaps regarding the impact of

policy adjustment, whether it is gradual or discontinuous at a particular debt level. Therefore, full interaction specifications considered with continuous value of debt distribution (incorporation of regime-dependent impacts) are as follows;

$$\begin{gathered}\text{ump}_{it} = \beta_0 + \beta_1 \text{def}_{it} + \beta_2 \text{regime}_{c,it} + \beta_3 \text{int}_{it} + \beta_4 \text{infl}_{it} + \beta_5 \text{m3}_{it} + \beta_6 \text{debt}_{it} + \beta_7 efi_{it} + \\ \beta_8\left(\text{def}_{it} \times \text{regime}_{c,\,it}\right) + \beta_9\left(\text{regime}_{c,it} \times \text{int}_{it}\right) + \beta_{10}\left(\text{regime}_{c,\,it} \times \text{infl}_{it}\right) + \beta_{11}\left(\text{regime}_{c,\,it} \times \text{m3}_{it}\right) + \\ \beta_{12}\left(\text{regime}_{c,\,it} \times \text{debt}_{it}\right) + \beta_{13}\left(\text{regime}_{c,\,it} \times \text{efi}_{it}\right) + \sum_{k=1}^{k} \gamma_k shock_k + \mu_i + \lambda_t + \epsilon_{it}\end{gathered} \tag{17}$$

3.4.2. Dynamic Lag Structure

Macroeconomic policies have a common tendency to influence unemployment with distributed lags consisting of costs of adjustment, diffusion of information, and multi-dimensional transmission channels at diversified speeds. For instance, the response of automatic stabilizers reflects their impacts immediately when discretionary spending influences aggregate demand after delays, even when considering the tax measures; it interacts with unemployment mitigation, incorporating further lags when households and firms need to adjust their behaviour. In the case of monetary policies, it is also operated with delays in the same manner. The transformation of policy rates first affects overall financial outcomes and later gradually shifts towards investment, consumption, and the demand in the labor market. The lagged variables $t-1$ for one quarter and $t-2$ for two quarter have been used as robustness checking tools. There is the generalized equation for the lagged FE-PTR interactions as follows

$$\begin{gathered}ump_{it} = \beta_0 + \beta_1 lagdef_{it} + \beta_2 regime_{it} + \beta_3 lagint_{it} + \beta_4 laginfl_{it} + \beta_5 lagm3_{it} + \beta_6 lagdebt_{it} + \beta_7 lagefi_{it} + \\ \beta_8(regime_{it} \times lagdef_{it}) + \beta_9(regime_{it} \times lagint_{it}) + \beta_{10}(regime_{it} \times laginfl_{it}) + \beta_{11}(regime_{it} \times \\ lagm3_{it}) + \beta_{12}(regime_{it} \times lagdebt_{it}) + \beta_{13}(regime_{it} \times lagefi_{it}) + \mu_i + \gamma_t + \varepsilon_{it}\end{gathered} \tag{18}$$

3.4.3. Driscoll-Kraay Standard Errors' Test

The Pesaran CD test, represented in Table 2, strongly acknowledges cross-sectional dependence across the EU member-states. This cross-sectional dependency reveals strong cross-sectional dependence among EU member states, reflecting deeper economic integration, synchronization of the business cycles, and common exposure in terms of economic shock conditions. Although estimators generated from the fixed-effect models remain consistent under these types of dependency, conventional standard errors are considered biased, which contributes to overwhelming statistical significance, as well as underestimates the reliability of threshold inference. In terms of regime-dependent effects of fiscal–monetary interactions, there is a common tendency for the inference to be hinged. In this regard, with a view to ensuring valid statistical inference, Driscoll–Kraay standard errors test has been conducted in this study to allow testing of consistent hypotheses as well as preserved unbiased estimations of coefficients in total across this panel threshold framework. Equation (18) has been developed using two-way fixed-effect estimators that contribute to eliminating which eliminates unobserved and constant country-level heterogeneity and common patterns of shock affecting all countries.

$$\hat{\beta} = (\widetilde{X}'\widetilde{X})^{-1}\widetilde{X}'\widetilde{y} \tag{19}$$

where $\widetilde{X}$ and $\widetilde{y}$ denote the demeaned regressors and dependent variable, respectively. Afterwards, the variance-covariance matrix of the estimator is as follows

$$Var^{DK}\widehat{(\beta)} = (\widetilde{X}'\widetilde{X})^{-1}\widehat{\Omega^{DK}}(\widetilde{X}'\widetilde{X})^{-1} \tag{20}$$

$$\sqrt{NT}\left(\hat{\beta}-\beta\right) \rightarrow N,(0, Var^{DK}(\widehat{\beta})) \tag{21}$$

Table 2. Panel unit root test result.

Variable	CD (*p*)	CIPS (*p*)	LLC (*p*)	IPS (*p*)
Ump	68.64 (0.00)	−1.91 (0.10)	−0.95 (0.17)	−0.85 (0.20)
Int	175.61 (0.00)	−3.18 (0.01)	−3.12 (0.001)	−2.98 (0.003)
Infl	140.63 (0.00)	−4.24 (0.01)	−4.10 (0.000)	−3.95 (0.000)
Debt	75.41 (0.00)	−1.40 (0.10)	−1.22 (0.11)	−1.10 (0.13)
Def	35.74 (0.00)	−2.62 (0.087)	−2.45 (0.007)	−2.30 (0.01)
M3	67.38 (0.00)	−2.27 (0.10)	−1.85 (0.032)	−1.75 (0.04)

3.4.4. Controls for Economic Shock Episodes

The twenty-first century has witnessed several unprecedented, extraordinary crisis episodes (2001Q1–2002Q4, 2008Q4–2012Q4, 2020Q1–2021Q4, 2022Q1–2022Q4) that have been counteract which have generated unemployment volatility across the EU-27 countries, which may create bias in coefficient estimation if not accounted for, making the usage of these shock dummy variables essential for differentiating normal policy driven mechanism to crisis-driven transmission.

$$\begin{aligned} ump_{it} = \beta_0 + \beta_1 def_{it} + \beta_2 int_{it} + \beta_3 infl_{it} + \beta_4 m3_{it} + \beta_5 debt_{it} + \beta_6 shock_{it} + \beta_7 efi_{it} + \gamma_1 (def_{it} \times regime_{it}) + \\ \gamma_2 (regime_{it} \times int_{it}) + \gamma_3 (regime_{it} \times infl_{it}) + \gamma_4 (regime_{it} \times m3_{it}) + \gamma_5 (regime_{it} \times debt_{it}) + \\ \gamma_6 (regime_{it} \times shock_{it}) + \gamma_7 (regime_{it} \times efi_{it}) + \alpha_i + \lambda_t + \epsilon_{it} \end{aligned} \tag{22}$$

In Equation (18), $shock_{it}$ has been used as a binary indicator during 2001Q1–2002Q4, 2008Q4–2012Q4, 2020Q1–2021Q4, and 2022Q1–2022Q4.

The next section presents empirical results, generating unit root test outcomes, followed by baseline PTR-FE estimates across multiple debt thresholds (binary and continuous), and concluding with robustness checks incorporating lagged effects and crisis interactions.

4. Results

The unit-root test results (Table 2) represent diversified integration across the selected variables. The Pesaran CD test strongly acknowledges cross-sectional interdependence across the EU-27 member states. Following the Pesaran CD test, this study conducted the second-generation CIPS test, which further identifies the non-stationary nature of Fiscal variables while monetary variables remain stationary. This CD and CIPS test result demonstrates their economic interconnectedness as well as their strong influence on one another.

Table 2 also incorporates the first-generation unit root tests (LLC and IPS) that determine some of the variables, like interest rate and inflation rate, as stationary, while on the other hand, unemployment rate and government debt to GDP are retained with a unit root. So, the panel data used in this study mostly represent a combination of I (0) and I (1) across the variables. This confirms the heterogeneous dynamics of the data set used in this study, which directly avoids any unrealistic approaches like homogeneity and independence of the countries and strengthens the empirical findings of this paper.

Afterwards, this heterogeneous integration order (non-uniformity, affected heterogeneous external shocks), stronger evidence of the cross-sectional interdependence as well as fiscal and monetary policy propagation across the border, furthermore, justify the adoption of Fixed-Effects Panel Threshold Regression (FE-PTR) with Robust Standard Errors as a baseline econometric framework for this study. This FE-PTR result, with the existence

of the diversified unit root test properties, represents their capabilities of heterogeneity handling, potential interdependence, followed by a non-linear relationship.

The regression results represented in Table 3 acknowledge the significant impact of the government budget deficit (% of GDP) on unemployment. Government deficits have a positive and higher significance (0.299 ***). It suggests that, at a low-debt regime, 1% increase in deficits come out with 0.299 percentage increase in unemployment. On the other hand, when considering the interaction between budget deficit and debt regime, the interacting coefficient (−0.241 ***) indicates that a high-debt regime (debt > 60% of GDP) contributes to weakening this relationship. Therefore, the total marginal impact is 0.299 − 0.241 = 0.058, demonstrating 81% reduction in magnitude. Government debt has a negatively significant association with unemployment, having a coefficient of −0.0371 ***, which is consistent with Keynesian economic thought predicting "expansionary government debt (through an increase in spending) results in a reduction in unemployment."

Table 3. Fixed-effects panel threshold regression (FE-PTR) results (60% threshold).

Variable	Estimate	Robust Std. Error	t-Value
Def	0.299 ***	0.0157	17.17
Debt	−0.0371 ***	0.0084	−4.415
Int	0.175 ***	0.0345	6.32
Infl	−0.147 ***	0.0182	−8.05
M3	−0.0146 ***	0.00218	−6.75
Def × regime	−0.241 ***	0.0162	−13.00
Int × regime	−0.0876	0.0602	−1.80
Infl × regime	−0.200 ***	0.0391	−5.16
M3 × regime	0.0116 **	0.00407	3.19
Debt × regime	0.0771 ***	0.00666	6.26
EFI × regime	−0.204 *	0.0793	−0.43

Significance code: *** $p < 0.01$; ** $p < 0.05$; and * $p < 0.10$.

While considering the monetary variables, interest rates (0.175 ***) have represented a positively significant co-efficient while on the other hand, inflation rate (−0.147 ***) and money supply M3 (−0.0146 ***) present statistically significant impacts on unemployment (negative). The interaction between regime specification (debt > 60% of GDP) and the selected variables in this study demonstrates heterogeneous impacts on unemployment. Particularly, fiscal deficits (−0.241 ***) and inflation (−0.200 ***) represent potential countercyclical impacts under elevated debt levels. On the other hand, M3 (0.0116 **) and government debt (0.0771 ***) are positively associated with unemployment under specific regime consideration. Another significant monetary indicator, "interest rates," denotes a negative and insignificant coefficient of −0.0876, whereas the economic freedom index (EFI) demonstrates a limited and marginal impact on unemployment mitigation (−0.204 *) on 60% debt regime, therefore strongly suggesting the requirement of stronger institutional capacities to maintain labor market flexibility.

Here, the positive coefficient generated from the deficits and interest rate demonstrates their contribution to rising unemployment, while debt, inflation, and money supply indicate their contribution to reducing it, which aligns with Keynesian perspectives (demand effects) and the Phillips curve. Under high-debt regime specifications, the interaction between unemployment and the positive effect of deficits is gradually reduced, which is partially followed by Ricardian behavior. This emphasizes the necessity of savings and crowding out as precautions from the debt-overhanging hypothesis in normal times. Negative association of inflation rate with unemployment represents similarity with the short-run Phillips Curve, while, on the other hand, weakening interest rate impacts are noted under high-debt regimes as an impaired monetary transmission mechanism under bindings of

fiscal constraints. However, a well-functioning institutional and monetary transmission framework when interacting with high-debt regimes is strongly recommended.

It can be rationalized in three ways. Firstly, high-debt regimes during the testing sample periods coincide with the unconventional ECB monetary policy comprised of different quantitative easing and negative rates initiatives. Those initiatives, by nature, contribute to suppressing interest rates and imposing constraints in crowding-out effect, which is how fiscal deficits affect the demand channels. Secondly, governments introduced high-debt regimes that are already under pressure from the labor market, may have shifted their deficits consumptions towards different employment-intensive programs against unemployment mitigation rather than direct general transfers. Also, this finding indicates stronger institutional influences of the high-debt countries at the third point.

The panel threshold regression (PTR) results across different debt-based regimes, following 50%, 60%, 70% thresholds in Table 4, identified that fiscal instruments are one of the major unemployment mitigating factors across the EU debt regimes. In the same table, government budget deficits have a positive and highly significant influence on unemployment mitigation (0.268 ***, 0.255 ***, and 0.245 ***), indicating that an imbalance in fiscal space (budget deficits) contributes to increasing unemployment. But while considering the impact of interest rate and debt on unemployment at the 50%, 60%, and 70% have been represented as statistically insignificant, indicating weakened monetary and fiscal transmission (respectively) following the increase in debt level. On the other hand, when inflation rate and money supply (M3) represent negatively significant coefficients respectively across all the thresholds (−0.2243 ***, −0.2109 ***and −0.2218 ***; −0.0147 *, −0.0138 *, and −0.0125 *). EFI represents consistently negative and insignificant correlation with unemployment across all the debt specification thresholds (−2.3652, −2.2661 and −2.2880).

Table 4. Fixed-effects panel threshold regression (FE-PTR) results across alternative thresholds (binary).

Variable	Debt $\geq$ 50%	Debt $\geq$ 60%	Debt $\geq$ 70%
Def	0.268 ***	0.255 ***	0.245 ***
Int	0.2355	0.1399	0.1461
Debt	0.0226	−0.0270	−0.0209
Infl	−0.2243 ***	−0.2109 ***	−0.2218 ***
M3	−0.0147 *	−0.0138 *	−0.0125 *
EFI	−2.3652	−2.2661	−2.2880
Def × regime	−0.2002 ***	−0.1923 ***	−0.1807 ***
Int × regime	−0.1937	−0.0807	−0.0963
Debt × regime	0.0065	0.0588	0.0431
Infl × regime	−0.1087	−0.1607	−0.171
M3 × regime	0.0182	0.009	0.0132
EFI × regime	−0.0038	−0.1230	−0.0409

Significance code: *** $p < 0.01$; ** $p < 0.05$; and * $p < 0.10$.

The interaction between fiscal deficits and debt regimes demonstrates consistently negative coefficients across all thresholds (−0.2002 ***, −0.1923 ***, and −0.1807 ***). Fiscal deficits contribute more effectively to unemployment mitigation once debt levels have risen, but with a small incremental gain. On the other hand, debt interaction is increasingly positive, with coefficients of (0.0065, 0.0588, and 0.0431, respectively), while considering monetary policy interactions under alternative debt regimes, interest rate and inflation rate represent significantly negative coefficients ranging from −0.1937 to −0.0963 and −0.1087 to −0.171. The liquidity expansion indicator M3 presents a positive influence on unemployment, but smaller in quantity. Finally, the interaction between the economic freedom index and the debt regime demonstrates continuously negative coefficients, suggesting that EFI may partially offset unemployment under a high-debt regime with limited magnitude (lim-

ited statistical significance). It indicates that institutional maintenance capacities influence unemployment, but not as robustly as fiscal and monetary indicators.

In the panel threshold regression with fixed effects (PTR-FE) in Table 5, Lags 1 and 2 represent the robustness of the threshold-dependent relationships among the key fiscal and monetary variables in the heterogeneous debt regime in unemployment mitigation. 1-Lagged value of government budget deficits represents a positive and highly significant effect on unemployment (0.148 ***), therefore, contributes to increasing unemployment in the short run, but its lag-2 estimation represents −0.039, as are partially offset. Both of the lagged values 1 and 2, considering interest rate and money supply, fail to represent statistical significance. Inflation rate and economic freedom index reduce unemployment at Lag-1 (−0.133 ** and −1.643 ** respectively), although both of them remain insignificant at lag-2 estimation.

Table 5. The panel threshold regression with PTR-FE with lag variables (60% threshold).

Variable	Lag-1 Estimate	Lag-2 Estimate
Lag Def	0.148 ***	−0.039
Lag Int	0.039	0.151
Lag Infl	−0.133 **	−0.015
Lag M3	−0.004	0.003
Lag Debt	−0.009	0.021 *
Lag EFI	−1.643 **	−0.443
Lag Def × Regime	0.254 **	−0.304 ***
Lag Int × Regime	0.136	−0.032
Lag Infl × Regime	−0.081	−0.032
Lag M3 × Regime	0.020 ***	−0.012 ***
Lag Debt × Regime	0.062 *	−0.027
Lag EFI × Regime	0.289	−0.501
Statistic	**Lag 1 (DK Robust)**	**Lag 2 (DK Robust)**
Mean Coefficient Estimate	−0.1820	−0.1644
Mean DK Std. Error	0.0866	0.0890
Mean t-Value	−0.0864	0.0552
Mean *p*-Value	0.1149	0.1860
Median Coefficient Estimate	0.0033	0.0033
Median DK Std. Error	0.0338	0.0352
Median *p*-Value	0.0118	0.0463

Significance code: *** $p < 0.01$; ** $p < 0.05$; and * $p < 0.10$.

Under the specified debt regime of 60% following the Maastricht criterion, short-run deficit raises unemployment in the short run (0.254 **) but demonstrates reverse characteristics on Lag-2 following the coefficient of −0.304 ***; therefore, it affirms a delayed gain of employment under fiscal expansion. Considering monetary expansion, it also has demonstrated a similar pattern; While M3 contributes to rising unemployment initially (0.020 ***), it gradually reduces at Lag-2 (−0.012 ***). Other estimations focusing on interest rates, inflation, debt, and EFI are statistically insignificant. Finally, the results generated from this lag structure, presented in Table 5, confirm the robustness and acknowledge the dynamic, threshold-dependent impact on unemployment.

Following Table 2, the Pesaran CD test result represents the cross-sectional independence, and in response, it is necessary to conduct the Driscoll–Kraay (DK) standard errors test with a view to strengthening the reliability of the PTR-FE estimation. Lag 1 and lag 2 both have presented consistent standard errors in DK correction procedures. This result confirms stabilized fiscal and monetary interactions despite having strong interdependence across countries and times.

While considering Lag 1, the mean coefficient is −0.1820, while the DK Standard error is 0.0866, having a median *p*-value of 0.0118, which confirms a significant interaction among deficit × regime, debt × regime, and money supply × regime. Lag 2 results represent a slightly smaller and negative result of mean −0.1644, DK SE 0.0890, and median *p*-value of 0.0463, which confirms both heterogeneity and robustness of the overall pattern.

The impact of fiscal policy represents comparatively stronger and stable coefficients across this specification. In Table 6, the government budget deficit (0.1110 *** in Model 1; 0.1123 *** in Model 2) denotes a positively significant coefficient indicating that expansion in fiscal deficits contributes to rising unemployment. Alongside, the interaction term between budget deficit and (debt) regime represents negatively significant coefficient for the model using heterogeneous interest rate (−0.0561 ***, −0.048 ***). It explores the comparative effectiveness of expansionary fiscal policy across high-debt regimes, which is completely associated with counter-cyclical stabilization theory.

Table 6. Comparison of baseline and heterogeneous interest rates (Eurozone and non-Eurozone).

Variable	Model 1 (Heterogeneous Interest Rate)	Model 2 (Baseline PTR)
Def	0.1110 ***	0.1123 ***
Infl	−0.1964 ***	−0.1781 ***
M3	−0.0035 *	−0.0035
Aggregate int	-	0.1135 *
Debt	0.0472 ***	0.0516 ***
Int (Eurozone)	−0.0203	-
Int (Non-Eurozone)	0.0504	-
EFI	−2.8758 ***	−15.4581 ***
Deficit × Debt regime	−0.0561 ***	−0.048 ***
Infl × Debt regime	−0.107 **	−0.047
M3 × Debt regime	0.0085 *	0.0058
Aggregate int × Regime	-	0.0901
Interest (Eurozone) × Regime	−0.2174 **	-
Interest (Non-Eurozone) × Regime	0.3440 ***	-
EFI × Regime	2.5004 ***	2.03 ***

Significance code: *** $p < 0.01$; ** $p < 0.05$; and * $p < 0.10$.

While considering Inflation, the determined coefficients following models 1 and 2 are −0.1964 *** vs. −0.1781 *** and therefore, represent a stronger negative impact, and government debt (0.0472 ***; 0.0516 ***) denotes a positively significant association that demonstrates quite consistent effects across both models. Inflation generates a stronger negative impact on unemployment while incorporating interest rate heterogeneity (−0.107 **), where baseline PTR is −0.047 **.

Government debt (0.0472 ***, and 0.0516 ***) remains positive and highly significant in both specifications, confirming a robust association between higher debt burdens and therefore triggering higher levels of unemployment across the independent nature of the monetary union. The money supply (M3) used in this study, which is weaker in nature, represents negative impacts for both the specification when −0.0035 for model 1 and −0.0035 (n.s) in model 2.

The regime effect can represent statistical significance under the existence of interest rate heterogeneity. Considering model 1, the regime dummy shows quite small and insignificant values (−0.0529), while in model 2, when it is incorporated with the heterogeneous interest rate, its coefficient becomes positive and statistically significant (1.2742 **). It clearly acknowledges the diversified nature of monetary transmission under different institutional capacities. The impact of interest rate has been represented quite differently, following this

table. The aggregate interest rate reported in this paper is positive but statistically limited in significance to 0.1135 *. Alongside Model 1, the Eurozone interest rate demonstrates a weakly significant negative value of −0.2174 **, while the Non-Eurozone interest rate comes with 0.3440 ***. Therefore, these values indicate the necessity of accounting for institutional heterogeneity across monetary transmission channels in terms of assessing the impact of interest rates on unemployment.

Finally, monetary policy indicators represent weaker interaction with the high-debt regime. Interest rate × regime interaction terms represent statistically insignificant values across both models. While considering the aggregate interest rate, it demonstrates quite moderate values for the interest rate following 0.1135 *.

This finding clearly indicates limited monetary traction during these elevated unemployment periods. The results represented in the table show that fiscal measures interact under different debt regimes with robustness in influencing unemployment, while interest rate policy effectiveness critically relies on the economic environment and institutional context. Specifically, Eurozone monetary policy effectiveness is insignificant under a high-debt regime.

When the shock dummy variables are included in Table 7, the baseline approach of the PTR FE model, the significant effect of exogenous shocks on unemployment reflects its regime dependency, following a coefficient of −1.1316 **. Since encountering shocks, different policy interventions or crisis-mitigating initiatives have been adopted promptly, which result in reductions of unemployment and reflect the necessity of the debt-level heterogeneity in the labor market.

Table 7. PTR fixed effects model with external shocks (60% threshold).

Variable	Estimate	Std. Error	t-Value
Def	0.1502 ***	0.0226	6.64
Debt	0.0145	0.0141	1.03
Int	0.1229	0.0635	1.94
Infl	−0.1642 ***	0.0339	−4.84
m3	−0.0038	0.0025	−1.51
EFI	−2.0462 ***	0.5985	−3.42
Def × regime	−0.0983 ***	0.0260	−3.78
Debt × regime	0.0524 ***	0.0144	3.64
Int × regime	0.0918	0.1020	0.90
Infl × regime	−0.0977	0.0553	−1.77
M3 × regime	0.0105 **	0.0038	2.77
Shock × regime	−1.1316 **	0.3827	−2.96
EFI × regime	−0.3113 ***	0.0884	−3.52

All specifications are included in Table 7 (shock dummy variables, country fixed effects, time fixed effects, and Driscoll–Kraay (HC3) standard errors) and *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 8 demonstrates the comparison across the selected fiscal-monetary policy variables used in this study under three alternative and continuous debt regimes of 50%, 60%, and 70%. The government budget deficits report, in this table, shows a positive and highly significant impact on unemployment across all the thresholds from 0.1980 *** at the 50% debt regime until 0.1855 *** at the 70% debt regime. It clearly points out that across the high-debt regime, expansionary fiscal policies lose their effective performance in controlling unemployment.

While considering the same deficit under regime interaction, it becomes negative and statistically significant following −0.1432 *** to −0.1149 ***. It is quite a common phenomenon that larger budget deficits always generate economic distress despite the

creation of new job opportunities under a high debt regime, and consequently result in the rise of unemployment despite fiscal expansion.

Table 8. Comparison of continuous debt regime specifications.

Variable	50% Debt Regime	60% Debt Regime	70% Debt Regime
Def	0.1980 ***	0.1665 ***	0.1855 ***
Int	0.1199	0.1050	0.0900
Infl	−0.0881 **	−0.0790 *	−0.0844 **
M3	−0.0060 **	−0.0039	−0.0038
Debt	0.0757 ***	0.0500 ***	0.0311 **
Def × regime	−0.1432 ***	−0.098 **	−0.1149 ***
Int × regime	−0.1837	0.0419	0.0477
Infl × regime	−0.055	−0.126	−0.111
EFI × regime	−0.1922 *	0.0074	−0.008
M3 × regime	0.0169 *	0.0147 ***	0.0294 ***

Regime thresholds denote continuous values of the debt ratio 50%, 60%, and 70% of GDP, where *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Interest rates show positive but statistically insignificant baseline effects (0.1199, 0.1050, and 0.0900 independently), and their interaction with the debt regime also remains statistically insignificant, pointing towards a weaker and non-regime-dependent monetary transmission. Inflation contributes to reducing unemployment (−0.0881, −0.0790 *, and −0.0844 **), according to the result represented in Table 8, but when incorporating with regime interaction, insignificance has been noted across higher thresholds. In the case of money supply, it represents a stable and negatively significant impact (−0.0060 **) at 50% debt threshold, but gradually, with the rising debt thresholds, it has kept on losing its significance. But being offset by high debt regimes, they have represented gradually stronger and significantly positive correlation with unemployment, following 0.0169 *, 0.0147 ***, and 0.0294 ***. Finally, while considering the economic freedom index (EFI), it could contribute to increasing unemployment significantly (although comparatively weaker) until it has crossed 50% debt thresholds, but gradually keeps on losing its traction and therefore starts to reduce unemployment at high debt regimes (−0.008 at 70% debt thresholds).

Overall, the results demonstrate that the main conclusions are robust to alternative continuous debt thresholds, reinforcing the validity of the smooth transition specification and highlighting the importance of accounting for nonlinear fiscal-labor market dynamics. This study provides robust evidence of nonlinearity and the conditional impact of fiscal and monetary transmission on debt dynamics in terms of magnitude, signs, and significance. Therefore, it underscores the necessity of incorporating continuous debt regimes along with binary regime specifications in EU labor-market analyses. The main findings of this paper represent empirical support for the Maastricht 60% debt threshold. It confirms the weakening of deficit–unemployment relationships when being contradicted above 60% of debt. This result suggests the importance of fiscal rules in the monetary union, which should be state-contingent, briefly followed before adaptation of any monetary policy stance and dealing with any kind of crisis context, rather than implementing a uniform pattern of consolidation.

5. Discussion

The empirical evidence from this study strongly affirms a structural break in the debt-to-GDP thresholds at 60% under the existence of counter-intuitive mechanisms. In a low-debt regime, expansionary budget deficits contribute to increasing unemployment, while in a high-debt regime, these same specifications represent a weaker effect (81%).

The main findings of the study demonstrate that expansionary fiscal measures are associated with higher unemployment in both the high- and low-debt regimes, but the magnitude of impacts becomes weak when this debt level crosses the threshold, keeping its direction unchanged. This same pattern persists in both binary and continuous regimes.

Although this result poses a question on conventional Keynesian predictions, it aligns with Ricardian equivalence mechanisms, where forward-looking agents highly motivate precautionary effects and crowding-out impact in response to the anticipation of future tax burdens generated from deficit spending (Roehn, 2010; Sardoni, 2021).

However, the limited effect generated from the high-debt regime has been found in this study basically follow three critical dynamics; when a nation undergoes high-debt episodes, several ECB interventions have been taken to ease the overall economic conditions, such as different QE or negative rates, which largely contributes in controlling borrowing costs and crowding-out mechanisms (Brunnermeier et al., 2016). Even countries intend to redirect these expansionary deficits towards different employment-intensive skill development programs (Hijzen & Martin, 2013) And overall, maintaining a flexible (accessible) market, as well as fiscal space, has been preserved through stronger institutional frameworks.

Although empirical validation has been achieved for the robustness of the 60% threshold following the Maastricht criterion, their transmission procedures have represented significant diversity rather than their earlier vision of fixing an absolute debt limit. Therefore, this 60% debt threshold has become the baseline for a structural shift in fiscal-labor market dynamics.

5.1. Impaired Monetary Transmission Under High Debt (H2)

Monetary policy impairment has been confirmed under high-debt regimes based on stronger empirical evidence presented in this study. The key reasons behind this Eurozone-specific impairment are generated from the existence of the zero lower bound constraints, which contributes in terminating conventional policy space (2012–2022) (Brunnermeier et al., 2016). Heterogeneous fiscal policy initiatives through which a simultaneous consolidation force is used to offset monetary stimulus outcomes. Continuous regime specifications shown in Table 8 have revealed a gradual degradation of policy transmission (existence of policy effectiveness on a continuum), rather than revealing that transmission degradation intensifies gradually rather than exhibiting sudden discontinuity.

The weak average of interest rate presented in this study clearly demonstrates the impairment of Euro and non-Eurozone countries under several regime specifications. It does not mean that monetary policy instruments are irrelevant; rather, it focuses on the institutionally contingent nature of debt thresholds. Moreover, due to the existence of the open market policies, as well as the existence of the monetary unions, restrict the individual performance in the Euro area and result in reduced responsiveness of the local labor market towards interest rate changes (Semmler & Haider, 2018).

On the other hand, when monetary and fiscal policies clash or when monetary transmission is impaired, the effectiveness of interest rate adjustments in unemployment mitigation initiatives becomes weaker. Furthermore, liquidity conditions and monetary aggregates, throughout this study, have been important even when traditional interest rate transmission mechanisms weaken (Barnett et al., 2024). This is how money supply has become one of the significant variables that has remained relevant for unemployment mitigation under shock conditions.

5.2. Crisis Amplification of Regime Asymmetries (H3)

The interaction between fiscal regime and shock conditions strongly indicates the positive contribution of crisis periods to unemployment mechanisms across diversified

countries as well as debt regimes. High-debt regimes tend to impose greater vulnerability in response to systemic shocks. Since limited fiscal space basically holds their capabilities in response to the counter-cyclical nature. On the other hand, low-debt regimes may retain good and flexible policy interactions through which they can handle labor market distortions more promptly in response to economic shock conditions, therefore acknowledging the asymmetric influence of the crisis period on unemployment throughout institutional and fiscal-policy channels.

Moreover, incorporating insignificant monetary policy indicators in response to the shock conditions denotes that they are mainly contributing to the stabilization of the financial conditions rather than supporting employment, especially where policy transmission is controlled by fiscal constraints.

Following the findings of the study, maintain consistency with the evidence that inflationary pressures have increased following the increases in the interest rate, which results in currency adjustments in an open economy, that is affecting the labor market dynamics (Egilsson, 2020). Several crisis episodes from 2000 to 2025, therefore, amplify these impacts following uncertainty and weaken conventional policy transmission. The result of the study acknowledges that repeated shocks further lead to a learning environment and well-framed institutional adaptation, leaving mechanical policy responses aside. Therefore, these observations maintain alignment with the existing studies that emphasize the role of uncertainty and risk imposed through several external shocks (Mpapalika & Malikane, 2019).

6. Conclusions

This study mainly examines regime-dependent fiscal and monetary interaction, which has been tested across the 27 EU countries using quarterly data from 2000 to 2025. Panel threshold regression with fixed effects has been conducted to test the effectiveness and systematic heterogeneity across different debt regimes defined by 50%, 60%, and 70% debt-to-GDP thresholds. Further, the reliability of the model has been checked with the inclusion of different lagged values as well as a shock dummy. The study has concluded with three principal findings: First, expansionary fiscal deficits contribute to increasing unemployment in both the low and high debt regimes, although it gradually declines by approximately 81% when crossing the benchmark of 60% debt threshold. The transformation (not reverse) of their magnitude is notified when debt regimes cross the benchmark of 60% threshold.

This counterintuitive reflection confirms that deficits can be prioritized less when debt is high. It seems to be driven by ECB monetary policy initiatives in response to the high debt episode, which eliminates the probability of the crowding-out effect, motivating compositional transformation in spending towards different employment-intensive programs in response to the contractionary labor market. Institutional selections play a vital role in this regard, following the credibility of sustaining higher levels of debt across multiple years, which is only possible in stronger economies.

Secondly, in this study, monetary variables represent insignificance in unemployment (no direct effects or limited ECB influences). Thirdly, limited interaction of shock with debt regimes ($\beta = -1.109$, $p = 0.005$) confirms the dependency of the labor market in response to the external shock on ultimate fiscal space availability. These findings reiterate the Maastricht 60% debt criterion as a structural threshold where fiscal policies shift, although different mechanisms exist based on treaty assumptions.

This study has been confronted with three core limitations. First, this study has emphasized one aggregate unemployment rather than categorizing them across several demographic groups, which may constrain the heterogeneous outcome of fiscal-monetary interactions. Secondly, the 60% debt threshold has emerged as a benchmark in this study, but country-specific institutional diversity may impose variations and, therefore, may

warrant the necessity of further investigations. Thirdly, the determined shock episodes can not be held responsible for the post-crisis shock duration and intensity. Therefore, it enhances the necessity to incorporate disaggregated assessment on youth and sectoral unemployment for future research with a view to identifying differential policy implications. Incorporation of other institutional variables beyond EFI and a more comprehensive investigation on the nonlinear interactions across fiscal and monetary policy indicators may potentially further enrich this research area.

This study has demonstrated nonlinear, regime-dependent interactions of the unemployment dynamics in the EU countries. In terms of fiscal deficits, it often contributes to elevating unemployment but therefore gradually become weaken when the country's maximum limit of thresholds has been crossed. It confirms the stabilizing impact of the institutional capacity (monetary accommodation) when confronted with the debt-intensive timeframe. Following this study, monetary instruments have represented a limited direct influence on unemployment mitigation, and therefore, it acknowledges fiscal tools as a primary channel in terms of labor market adjustment in the monetary unions. The significant participation of different shock variables, which have a diversified impact on existing fiscal spaces of a country, furthermore, underscores the necessity of flexible, state-contingent policy structures due to uniform fiscal stances being insufficient.

The findings of this study recommend that the EU governance system transform itself from one-for-all fiscal regulations towards state-dependent frameworks. These fiscal and monetary rules can only perform effectively when they are maintained with internal coordination. In this regard, institutional quality enlargement has become a mandatory prerequisite that can contribute to developing counter-cyclical fiscal buffers to generate adequate spaces in response to shock conditions and get rid of sole dependency on monetary accommodation.

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