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From skies to markets implications of extreme weather events for macroeconomic and financial imbalances in CESEE countries

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FROM SKIES TO MARKETS IMPLICATIONS OF EXTREME WEATHER EVENTS FOR MACROECONOMIC AND FINANCIAL IMBALANCES IN CESEE COUNTRIES

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IES Working Paper 5/2025

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From Skies to Markets Implications of Extreme Weather Events for Macroeconomic and Financial Imbalances in CESEE Countries

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Abstract:
This study explores the heterogeneous and asymmetric macro-financial effects of climate change in CESEE countries, depending on the level of underlying macro-financial vulnerabilities. Focusing solely on acute physical risks - those arising from extreme weather events – it employs panel quantile regression analysis to examine data from 2000Q1-2022Q4 for 17 countries in the region. Notably, we find that climate shocks exacerbate macroeconomic and financial imbalances, increasing the susceptibility of already vulnerable economies to additional risks. Specifically, countries with higher economic imbalances suffer more severe output disruptions and heightened inflationary pressures following a climate shock. While the impact of climate shocks on external imbalances may be less pronounced, countries with existing vulnerabilities may still encounter pressures on trade and competitiveness. Additionally, climate shocks can intensify financial vulnerabilities for countries already grappling with lower levels of financial resilience.

JEL: E52, E51, E61, E63, E65
Keywords: extreme weather events, macro-financial vulnerabilities, CESEE countries, panel quantile regression analysis

1. Introduction

As the world grapples with the need to balance economic growth with environmental sustainability, assessing the effects of extreme weather events becomes increasingly critical. The growing frequency and severity of extreme weather events (NASA, 2024; European Environmental Agency, 2024) trigger both short-term and long-term disruptions that weaken economic activity, increase inflation volatility, and destabilize financial markets. They do so by damaging infrastructure and capital stocks, lower labor productivity (Donadelli et al., 2017; Matsumoto, 2019), straining supply chains. Weather conditions also disrupt key sectors such as agriculture and energy (Gonçalves et al., 2024; Crofils et al. 2025) and alter investment behavior (Moore and Diaz, 2015; Liu et al., 2023; Ahmed et al., 2024). All these result in reinforcing inflationary pressures and worsening macro-financial vulnerabilities (Deryugina and Hsiang, 2014; Kahn et al., 2021; Alessandri and Mumtaz, 2021; Kahn et al. 2023; Qi et al., 2025).

Climate change also influences international trade. Severe weather events disrupt trade by reducing exports and increasing import demand, especially in vulnerable economies (Gassebner et al., 2010; Brenton, Chemutai, 2021). However, they can also boost imports for recovery and create opportunities for developed economies (Liu et al., 2023). Climate risks may further expand trade in disaster response, renewable energy, and sustainable infrastructure.

Beyond its macroeconomic consequences, weather events present risks to financial stability too. They destabilize financial markets through credit risk propagation, asset repricing, and rising sovereign debt burdens (Batten et al, 2020; Diluiso et al., 2023). Unlike standard economic shocks, climate risks can push economies past tipping points, leading to prolonged financial distress and stagnation (Steffen et al., 2018; Lenton et al., 2019). These risks are also

highly endogenous, as their severity depends on market expectations and policy responses (Battiston, 2019).

Despite the growing recognition of the economic and financial implications of extreme weather events, empirical research on their macro-financial effects remains limited, particularly for vulnerable regions. Also, traditional economic models typically assess average effects, neglecting the asymmetries and heterogeneities between countries. They typically fail to capture how climate shocks amplify existing risks (Burke, Hsiang, and Miguel, 2015; Kalkuhl and Wenz, 2020).

Our paper contributes to this understanding, by addressing this gap in the existing literature. It empirically examines how extreme weather events exacerbate macro-financial imbalances, particularly in structurally weaker economies within Central Eastern South-Eastern Europe - a region largely overlooked in climate-related macro-financial studies. Specifically, this study seeks to answer the following research question: *Does exposure to acute physical risks, stemming from extreme weather events, intensify existing vulnerabilities within the CESEE region, and how do these shocks amplify macroeconomic and financial imbalances?*

The macro-financial effects of weather events are particularly concerning for this region, due to its exposure to heightened macro-financial imbalances (IMF, 2023). Additionally, parts of the region face Europe's most severe droughts (Maes et al., 2022), while many CESEE growth models are increasingly vulnerable to global shifts (Lagarde, 2023), further amplifying climate risk exposure.

Another key contribution of our study is the explicit focus on macro-financial vulnerabilities. Unlike existing research that primarily examines individual macroeconomic and financial indicators, we construct composite measures of macro-financial imbalances, encompassing both internal and external economic fragilities, as well as financial sector

vulnerabilities, in line with the growing recognition among global institutions, such as the IMF, BIS, and ECB.

By employing a panel quantile regression (PQREG) model, we move beyond conventional mean-based analyses and we capture the heterogeneous and asymmetric effects of climate shocks, utilizing data from 17 economies in the CESEE region spanning the period from 2000 to 2022. Our findings reveal that the macro-financial consequences of extreme weather events are highly dependent on underlying economic conditions. Economies with pre-existing vulnerabilities, such as large output gaps and inflationary pressures, experience disproportionately severe and prolonged disruptions, reinforcing structural weaknesses. Climate shocks amplify external imbalances and depreciation pressures in countries with initially undervalued exchange rates, raising import costs and inflation; while in economies with overvalued currencies, they exacerbate REER misalignments, reducing competitiveness and worsening trade deficits. These effects are particularly severe in economies with weaker financial buffers. Climate shocks also heighten financial vulnerabilities, particularly in economies with weaker banking sectors and higher financial stress.

The rest of the paper is structured as follows. Section 2 provides an overview of the empirical literature on this topic. Section 3 outlines the methodology and explains the dataset. Section 4 presents the findings of the empirical analysis and Section 5 provides concluding remarks, summarizing the key findings and their implications.

2. Literature Review

The literature review is structured into two main sections: the first explores the evolution of macroeconomic models that integrate extreme weather events, while the second reviews empirical studies on their macro-financial effects, identifying also the limitations of existing research in capturing heterogeneous and asymmetric effects.

2.1 Theoretical Foundation: The Evolution of Macroeconomic Models Integrating Extreme Weather Events

This section traces the theoretical evolution of climate risk integration into macro-financial stability models, moving from traditional economic growth models to modern financial risk and monetary policy frameworks that account for climate-induced instabilities. The integration of extreme weather events into macroeconomic modeling has evolved over time, reflecting a growing recognition of their impact on economic stability and financial resilience.

Early neoclassical growth models primarily treated extreme weather events as exogenous shocks to capital stock. These models, rooted in the Solow-Swan framework, assumed that economies would recover through investment and reconstruction, leading to a return to their long-run growth trajectories. However, this framework did not account for the persistent economic scarring that extreme weather events can cause, particularly in structurally fragile economies. The endogenous growth theory later refined this approach by acknowledging that climate-induced disruptions could affect innovation, human capital accumulation, and long-term productivity. Studies such as Fankhauser and Tol (2005) and Lecocq and Shalizi (2007) integrated climate-related damages into growth models, demonstrating that extreme weather events could lower the steady-state growth rate by discouraging investment and technological progress.

Computable General Equilibrium (CGE) models offered a more detailed framework for assessing the impact of extreme weather events on macroeconomic dynamics. Unlike growth models, which focus on long-run effects, CGE models simulate short- and medium-term economic responses by incorporating sectoral interdependencies and price adjustments. Moore and Diaz (2015) extended CGE models by explicitly integrating investment behavior shifts due to climate uncertainty, illustrating how extreme weather events create prolonged economic

distortions by altering investor expectations and risk assessments. While CGE models improved upon growth models by capturing indirect effects, they often rely on equilibrium assumptions that may not fully account for financial market disruptions.

Input-Output (I-O) models further advanced the analysis of extreme weather events by examining how supply chain disruptions propagate across industries. These models allowed researchers to quantify the indirect economic costs of climate shocks by tracking production linkages and dependencies. Although I-O models are useful for assessing short-term economic losses, they assume fixed production structures and do not incorporate dynamic financial feedback loops, limiting their ability to capture long-term macro-financial risks.

Integrated Assessment Models (IAMs) were developed to link climate science with macroeconomic projections, primarily for evaluating long-term climate policy. The Dynamic Integrated Climate-Economy (DICE) model introduced by Nordhaus (1991) was one of the first IAMs to include climate damages as a function of temperature increases, estimating their effects on output and consumption. Subsequent IAMs such as RICE and PAGE refined this approach by incorporating regional heterogeneity and uncertainty. However, IAMs typically rely on smooth damage functions that may underestimate the non-linear effects of extreme weather events, particularly their role in triggering financial instability.

Traditional macroeconomic models based on neoclassical growth theory assumed that climate shocks had only short-term effects, as capital accumulation and technological progress would drive recovery over time. Studies such as Dell, Jones, and Olken (2012) and Burke, Hsiang, and Miguel (2015) extended neoclassical growth models to the domain of climate economics, finding that temperature shocks negatively affected productivity and economic growth. Felbermayr and Gröschl (2014) built on these foundations by differentiating between geophysical and meteorological disasters, demonstrating that developing economies faced prolonged economic downturns due to weaker financial and institutional resilience.

Over time, theoretical models evolved to incorporate financial system risks, recognizing that extreme weather events could disrupt investment, lending, and sovereign debt markets, creating vulnerabilities that extended beyond short-term economic shocks. Battiston et al. (2017) introduced a network-based financial contagion model to assess how climate-related shocks propagate through the financial system. This model demonstrated that financial institutions are interconnected through cross-exposures to carbon-intensive assets, meaning that extreme weather events and transition risks could trigger systemic financial instability. Monasterolo (2020) extended this work by developing a climate stress-testing framework that integrated credit risk transmission, market liquidity stress, and central bank policy responses. These advances shifted the understanding of climate-related macro-financial risks from being purely exogenous to recognizing their deep integration into financial market structures.

Feyen et al. (2020) introduced the "double jeopardy hypothesis", which argues that economies with pre-existing macro-financial vulnerabilities are disproportionately affected by climate risks. Another key theoretical development involved integrating climate risk considerations into monetary policy frameworks. Batten, Sowerbutts, and Tanaka (2020) applied a New Keynesian monetary framework to analyze how climate risks affect inflation and central bank policy effectiveness. Their model demonstrated that climate risks create inflation volatility, reducing the ability of central banks to stabilize financial markets through conventional policy tools.

More recent theoretical advances have focused on modeling the nonlinear and asymmetric risks that extreme weather events pose to financial stability. Adrian et al. (2019) introduced the Growth-at-Risk (GaR) framework, which employs quantile regression models to assess the tail risks of climate-related financial instability. Unlike traditional macroeconomic models, GaR accounts for heterogeneous impacts across different economic conditions,

demonstrating that financially weaker economies suffer greater downside risks from extreme weather events.

Dynamic general equilibrium (DGE) models have also been extended to incorporate climate risks. Diluiso et al. (2023) developed a New Keynesian DSGE model that integrates financial frictions and heterogeneous sectoral exposure to climate risk. Their model demonstrated that climate-related financial risks can lead to mispricing of assets, credit market distortions, and financial instability, particularly in economies reliant on fossil-intensive industries. Similarly, Gagliardi, Arévalo, and Pamies (2022) applied a Debt Sustainability Analysis (DSA) framework to evaluate how climate-induced fiscal shocks affect sovereign risk and debt markets. Their findings reinforced the idea that economies with limited fiscal space face a higher risk of sovereign debt crises following extreme weather shocks.

2.2 Related Empirical Evidence

There is a growing empirical literature on quantifying the macro-financial effects of climate-related shocks. Several studies confirm that extreme weather events are primarily negative supply shocks, adversely affecting growth and inflation (Cashin et al., 2017; Kabundi et al., 2022; Kim et al., 2022; Cevik and Jalles, 2023).

Differences in the economic impact of extreme weather between high- and low-income countries have been widely documented. While higher-income countries tend to suffer greater direct property losses from natural disasters, they experience lower fatalities and smaller economic contractions due to better infrastructure, stronger institutions, and more resilient economies (Hsiang and Jina, 2013; Felbermayr and Gröschl, 2014).

In line with this, Klomp and Valckx (2014) conducted a meta-analysis of 25 studies, finding that climatic disasters in developing countries have the most severe and persistent

impacts, highlighting the vulnerability of economies with weaker financial systems. Felbermayr and Gröschl (2014) show that poor countries are more strongly affected by geophysical disasters. Also, Burke et al. (2015), Faccia et al. (2021) and Phan and Schwartzman (2024) further emphasize the disproportionate and the long-lasting impact of climate shocks on vulnerable economies.

Similarly, Cevik and Jalles (2024), using data from 173 countries between 1970 and 2020, found that extreme weather events lead to significant and persistent declines in growth in developing economies, whereas no long-term effects were observed in advanced economies. Their study also highlights nonlinear effects, showing that climate shocks have a greater impact during economic downturns, exacerbating income and inflationary pressures. Usman (2024) analyzes the medium-run macroeconomic effects of extreme climate events - heatwaves, droughts, and floods - across 1,160 regions in the EU. Heatwaves and droughts cause prolonged output losses, especially in lower-income regions, which struggle with financial constraints. In contrast, high-income regions recover faster from floods, benefiting from reconstruction-driven investment, while poorer regions do not.

Various studies confirm the inflationary effects of extreme weather events (Heinen et al., 2019; Mukherjee and Ouattara, 2021; Qi et al., 2025). Parker (2018) finds differing inflation effects of the extreme weather events by level of development for 212 countries. The overall impact for advanced economies is modest, but for developing economies it can be substantial and persist over time. Using panel local projections for 48 advanced and emerging economies, including several European countries, Faccia et al. (2021) find that hot summers drive short-term food price inflation, especially in emerging markets, but have limited or negative effects on broader price indices over the medium term. Their analysis highlights non-linear effects, with stronger impacts from extreme temperature shocks. Kabundi et al. (2022) finds that the

inflationary effects depend on the type and intensity of shocks, income levels, and monetary policy regimes. Over the long run, supply-driven climate shocks may weaken the effectiveness of inflation-targeting monetary policies, particularly in low-income developing countries. Li et al. (2023) found that inflation responses to temperature shocks vary widely across 26 countries, with stronger effects in developing economies. Ciccarelli et al. (2023) assessed the impact of climate shocks on inflation in the four largest Eurozone economies. They found that national asymmetries exist, with food, energy, and service prices responding differently across countries, particularly in summer and autumn.

Qi et al. (2025) analyze the impact of climate change on inflation using data from 101 countries (2006–2019) with a GMM approach. Their findings show that climate change significantly raises inflation in the short term, particularly in low-income countries, but has no long-term effect.

Extreme weather events have significant effects on external imbalances as well. Oh and Reuveny (2010) first identified that climate-related disasters increase import dependence, as affected countries rely on external goods for reconstruction, worsening trade deficits. Gassebner, Keck, and Teh (2010) showed that economies frequently exposed to extreme weather gradually shift their trade structures to reduce reliance on vulnerable sectors, though this transition is often slow and leads to prolonged external imbalances.

Felbermayr and Gröschl (2014) found that natural disasters significantly reduce exports, particularly in developing economies with weaker infrastructure and financial constraints. Berlemann and Steinhardt (2017) later showed that while high-income economies experience temporary trade deficits due to increased reconstruction-related imports, they recover as exports rebound. In contrast, low-income countries face persistent trade imbalances due to financial constraints limiting their recovery.

Boehm, Flaaen, and Pandalai-Nayar (2019) emphasized the role of global trade networks, showing that climate shocks in one country disrupt international supply chains, creating spillovers for trading partners. Kubota, Okubo, and Saito (2021) further demonstrated that economies integrated into global production networks experience rising trade deficits after extreme weather events due to supply chain disruptions.

In terms of the link between climate shocks and financial stability, studies have highlighted various transmission mechanisms. As regards, the link between climate shocks and financial stability, Roncoroni et al. (2021) used a network model to show how interconnected financial markets amplify climate-related instability, leading to increased contagion risks across borders. Garbarino and Guin (2020) examined the UK's mortgage market post-flood events, revealing that banks often fail to adjust their risk pricing despite heightened climate risks, exacerbating vulnerabilities in the financial sector. Similarly, Flori et al. (2020) utilized a vector autoregression model to explore the effects of climate shocks on commodity price fluctuations and financial stress, finding that disruptions in commodity markets propagate through the financial system, affecting lending and investment decisions. Dafermos and Nikolaidi (2020) focused on the interaction between financial regulation, fiscal policies, and banking system resilience, noting that while green finance initiatives, such as lower capital requirements for green loans, promote sustainability, they can increase financial fragility without complementary fiscal policies. Lamperti et al. (2020) emphasized that inadequate adaptation strategies in financial institutions could lead to systemic instability, particularly in markets where climate risks are undervalued. Additionally, Cevik and Jalles (2023) applied the local projection method to show that climate shocks exacerbate financial fragility, disproportionately harming economies with weaker fiscal buffers. The role of extreme weather in increasing credit risk has also been documented. Calabrese et al. (2024) demonstrated that extreme weather events increase mortgage default probabilities, particularly in regions exposed

to frequent climate shocks.

Despite the growing recognition of the economic and financial implications of extreme weather events, empirical research on their macro-financial effects remains limited, particularly for European regions, and especially for the most vulnerable economies. Also, much of this research tends to focus on average effects, often overlooking the critical asymmetries and heterogeneities between countries, failing to account for how climate shocks interact with and amplify pre-existing vulnerabilities. Our study addresses these gaps by focusing specifically on the macro-financial effects of extreme weather events in CESEE countries, a region that, despite being the most vulnerable in Europe, has received limited attention in existing literature. We also capture the distributional effects, considering the varying vulnerabilities across countries to examine how climate shocks interact with pre-existing economic weaknesses - such as trade deficits, inflationary pressures, economic slack and financial fragility.

3. Empirical Analysis

3.1 The Model Framework

A defining characteristic of climate risk is its uneven and asymmetric nature, which challenges conventional macroeconomic and financial frameworks (Adrian et al., 2019; Kalkuhl and Wenz, 2020; Bolton et al., 2020; Monasterolo and Battiston, 2020; Dafermos, 2021; Kiley, 2024). Using a panel quantile regression (PQREG) model is particularly effective for examining the impacts of extreme weather events on macroeconomic and financial imbalances, primarily due to its ability to capture tail events and its relevance to the unique characteristics of such phenomena.

This approach allows us to analyse not only the average effects of extreme weather events, but also the tail risks, capturing how these events influence macro-financial imbalances

across different points of the distribution, such as in periods of severe economic stress or financial instability.

The PQREG model is expressed as follows:

$$Q_{\pi}(\tau|X_{it}) = \alpha_i + \beta(\tau) * \chi_{it} + u_{it} \qquad (1)$$

where $Q_{\pi}(\tau|X_t)$ represents the τ-quantile of each of the measures of macroeconomic and financial imbalances, used as dependent variable Y_{it}; α_i is the country-specific fixed effect, capturing unobserved heterogeneity across countries; $\beta(\tau)$ is the vector of coefficients associated with the independent variables χ_{it} which can vary depending on the quantile τ; u_{it} is the error term, which captures unobserved factors affecting Y_{it}.

In our analysis, we estimate coefficients across ten quantiles, ranging from the 10th to the 90th percentiles, to capture how the impact of extreme weather events differs at varying degrees of macroeconomic and financial imbalances. Confidence intervals are computed using bootstrapping with 500 replications. Each predicted quantile corresponds to a point in the cumulative distribution function (CDF) of the dependent variables - macroeconomic and financial imbalances. By mapping these discrete quantile estimates over time, we generate a sequence of probability density functions (PDFs) for the dynamics of these imbalances.

Before proceeding with the empirical analysis, we formally outline the key hypotheses tested in this study. Based on the theoretical and empirical literature, we test the following hypotheses (both null and alternative):

H_0: Extreme weather events do not have a significant or asymmetric impact on macroeconomic imbalances (output gap, inflation, external, and financial imbalances) across CESEE economies.

H_1: Extreme weather events have a significant and asymmetric impact on macroeconomic imbalances (output gap, inflation, external, and financial imbalances) across CESEE

economies. This expectation follows from the notion that climate shocks act as negative supply shocks, with potentially more severe effects in economies with higher vulnerabilities.

H_0 (H_{1a}): Climate shocks do not deepen recessions when economies experience negative output gaps by further reducing output.

H_1 (H_{1a}): Climate shocks deepen recessions when economies experience negative output gaps by further reducing output.

H_0 (H_{1b}): Climate shocks do not amplify inflation when economies operate under high price volatility.

H_1 (H_{1b}): Climate shocks amplify inflation when economies operate under high price volatility.

H_0 (H_{1c}): Climate shocks do not widen current account deficits or surpluses when economies experience external imbalances.

H_1 (H_{1c}): Climate shocks widen current account deficits or surpluses when economies experience external imbalances.

H_0 (H_{1d}): Climate shocks do not exacerbate exchange rate misalignments when economies face overvalued or undervalued currencies.

H_1 (H_{1d}): Climate shocks exacerbate exchange rate misalignments when economies face overvalued or undervalued currencies.

H_0 (H_{1e}): Climate shocks do not increase financial instability when economies operate with weaker financial buffers.

H_1 (H_{1e}): Climate shocks increase financial instability when economies operate with weaker financial buffers.

H_0: The impact of extreme weather events on macroeconomic imbalances does not vary across country groups within CESEE, reflecting no significant differences in economic structure, institutional resilience, and financial integration.

H_2: The impact of extreme weather events on macroeconomic imbalances varies across country groups within CESEE, reflecting differences in economic structure, institutional resilience, and financial integration.

This framework allows us to examine both the asymmetric impacts of climate shocks and the heterogeneous responses across CESEE economies.

3.2 Data Description

3.2.1 Selected Macroeconomic and Financial Variables

Our analysis focuses on a panel comprising 17 emerging economies in the Central, Eastern, and South-Eastern Europe (CESEE) region. The countries considered are Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Montenegro, North Macedonia, Poland, Romania, Serbia, Slovak Republic, and Slovenia. Since a common monetary policy is being conducted by the European Central Bank for the Euro Area countries, these countries are grouped together. Countries and time periods are chosen with respect to data availability. The dataset consists of quarterly data spanning from 2000 to 2022.

In the pursuit of evaluating macroeconomic and financial imbalances and spillovers in the CESEE region attributed to extreme weather conditions, various explanatory variables are employed as proxies for these imbalances. These variables are selected based on their alignment with existing literature, identifying them as the most pertinent indicators for capturing macro-financial relationships.

Output gap used to gauge internal imbalances, is calculated as the difference between actual GDP and potential GDP. The latter is estimated using the Hodrick-Prescott (HP) filter. In assessing external current-account imbalances, we rely on the current-account gap, which is

defined as the difference between the observed current account and its estimated equilibrium value. Inflation is represented by the percentage variation in the natural logarithm of the Consumer Price Index, and it undergoes seasonal adjustment. The variables are extracted from the respective national statistical offices of the considered countries and Eurostat database. The theoretical justification for these two variables lies in their association with macroeconomic stability, a premise supported by previous studies (Romer & Romer, 2004; Olivei & Tenreyo, 2007; Coibion, 2012; Cloyne & Hürtegren, 2016; Champagne & Sekkel, 2017).

Determining financial stability is inherently more intricate than assessing aspects such as price stability. The complexity arises due to the intertwined nature of various elements within the financial system and their multifaceted interactions, both internally and with the broader real economy (Gadanecz & Jayaram, 2009). It will be assessed using the CAELS and CAMELS methods.

When evaluating external current-account imbalances, we utilize the current-account gap, which represents the deviation of the observed current account from its estimated equilibrium level. In the same vein, exchange-rate discrepancies are defined by the gap between the actual real effective exchange rate and its estimated equilibrium level through HP filter. The equilibrium value for the current account is derived from models incorporating traditional economic fundamentals. The detailed process of estimating the FSI and current account gap will be discussed in the sub-sections 3.2.3 and 3.2.4, respectively.

3.2.2 The European Extreme Events Climate Index

Figure 1 reveals an upward trend in the frequency and intensity of extreme weather events across some of the countries in the region. Over time, these events have not only become more frequent, but also exhibit heightened volatility, with sharp fluctuations in the index

values. This increased variability underscores the growing unpredictability of extreme weather, making it challenging for communities and policymakers to anticipate and manage risks effectively. The index's rising trajectory indicates the intensifying impact of climate change, as regions experience more erratic heatwaves, droughts, storms, and other hazards (European Environment Agency, 2024). Such shifting of extreme weather patterns beyond historical norms reinforces the need for adaptive strategies and robust resilience measures.

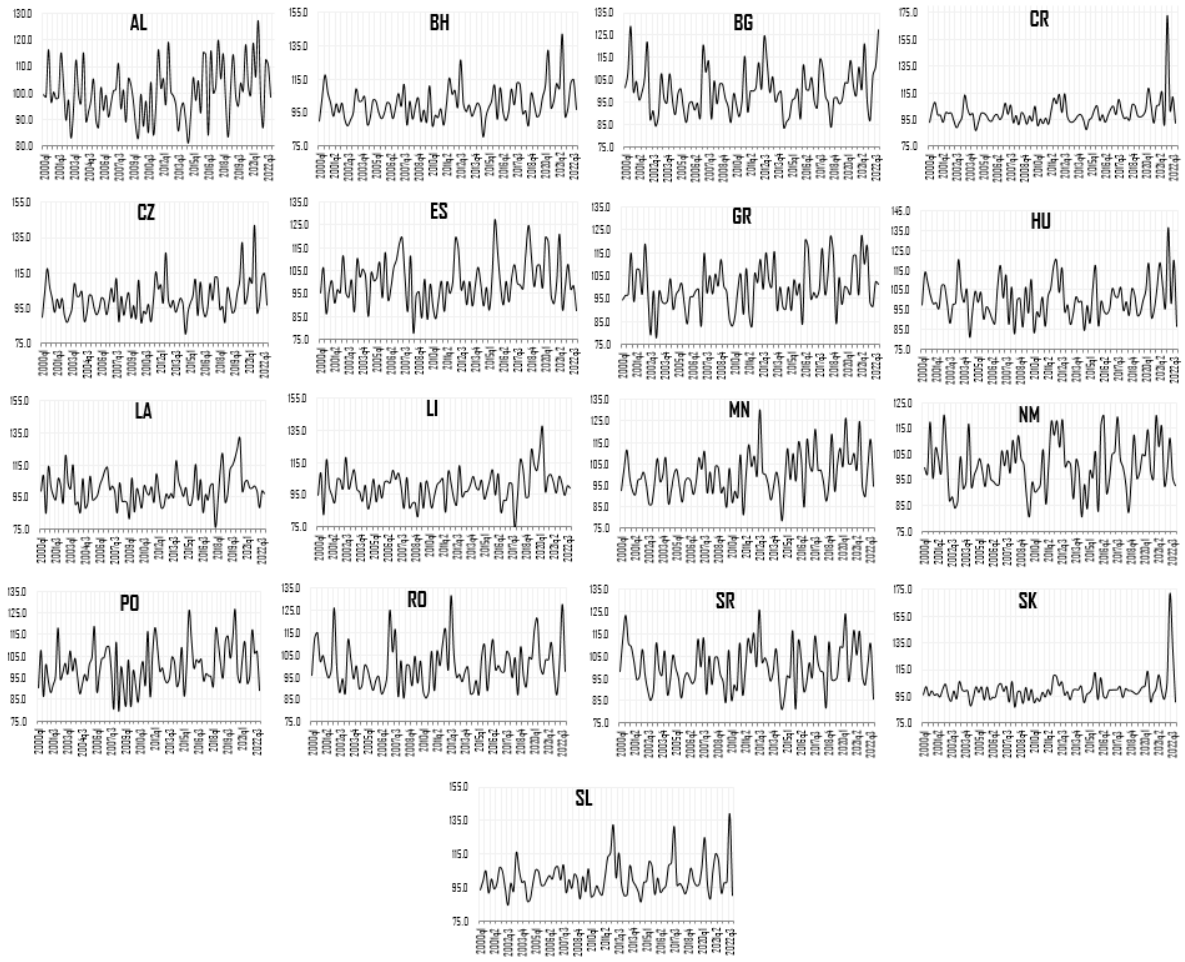

Figure 1. Extreme weather events index in the CESEE region.

Source: IFAB, 2024.

The European Extreme Events Climate Index (E3CI) is a comprehensive tool designed to observe, map, and monitor the frequency and intensity of extreme weather events impacting European territories and communities. It offers immediately useful data for

identifying trends and formulating projections on national, regional, and provincial levels. E3CI is based on the Copernicus ERA5 dataset, the fifth generation of atmospheric reanalysis produced by the European Centre for Medium-Range Weather Forecasts (ECMWF). ERA5 provides global coverage from 1950 onward, and it delivers monthly information on climate anomalies, enabling both retrospective analyses and forward-looking projections that support effective management and resilience strategies.

The E3CI focuses on seven core climate dynamics associated with extreme weather events: extreme maximum temperatures, extreme minimum temperatures, extreme precipitation, extreme winds, hail, drought, and fires. Each component measures how monthly values deviate from historical averages, with reference values based on the 1981–2010 period. The index's standardized anomalies capture deviations from these baseline conditions, offering a clear picture of current weather-related stress on specific areas. For example, extreme maximum temperatures reflect the cumulative exceedance of daily highs above the 95th percentile of the reference period, while extreme minimum temperatures capture deviations of daily lows below the 5th percentile. Droughts are assessed using the Standardized Precipitation Index (SPI), comparing rainfall deficits over three months to historical averages. Similarly, extreme precipitation events are monitored through rainfall amounts exceeding the 95th percentile, helping to identify flood risks.

The index also tracks hail events using the Significant Hail Parameter (SHIP), which signals days with a high probability of hailstorms. Extreme wind speeds, measured by the exceedance of the 95th percentile, highlight periods prone to damaging winds or storms. Fire risk is evaluated using the Fire Weather Index (FWI), which monitors conditions favorable for wildfires when daily values surpass key thresholds. By averaging the values from all seven

components, the E3CI provides a composite score that offers a multidimensional view of extreme weather events.

3.2.3 Medium-term Current-account Estimation

The current account gap, denoted as CA^{gap} , is defined as follows:

$$CA_{i,t}^{gap} = CA_{i.t} - \widehat{CA_{i,t}} \quad (2)$$

where $CA_{i.t}$ represents the observed current account (in percentage of GDP) and $\widehat{CA_{i,t}}$ the estimated equilibrium value. The latter is given by estimating:

$$CA_{i,t} = \alpha_i + \sum_{j=1}^{n} b_j Z_{i,t} + \mu_{i,t} \quad (3)$$

where n denotes the number of explanatory variables $Z_{i,t}$, $\mu_{i,t}$ is an i.i.d. error term, and a_i captures the country-fixed effects. Specifically, regarding the current account, the following determinants have been retained: fiscal balance (fisc_gdp), lagged net foreign asset position (nfa_gdp), relative level of PPP-adjusted GDP per capita, relative GDP growth rate, aging rate, old-age dependency ratio, population growth rate, M2 to GDP ratio, degree of openness, terms of trade, and oil balance, in line with the most prominent literature (Lane and Milesi-Ferretti, 2012; Ca'Zorzi et al., 2012; Medina et al., 2010; Lee et al., 2008). All data used for the estimation of CA norm and their respective sources are given in Table A1 in the Appendix.

Turning to the equilibrium exchange-rate model, we have expressed the real effective exchange rate as a function of the net foreign asset position (in percentage of GDP) and a proxy for relative productivity. All data used and their sources are given in Table A1 in the Appendix.

The positive link between the fiscal balance and the current account can be explained by the impact of fiscal policy on national savings and intergenerational income redistribution.

An improvement in the fiscal balance, such as achieving a surplus or reducing a deficit, tends to increase national savings by lowering government borrowing and interest rates. This, in turn, contributes to a surplus in the current account.

The positive link between net foreign asset (NFA) position and the current account is established through the impact of an improved NFA position on net investment income. When a country becomes a net creditor, owning more foreign assets than liabilities, it experiences an increase in net investment income. This income, comprising interest, dividends, and profits from foreign investments, directly contributes to the current account, leading to a surplus. In essence, a positive NFA position signifies that the country earns more from its international assets than it pays on foreign liabilities, reinforcing the connection between NFA and the overall external balance.

The link between GDP per capita and GDP growth and the current account is multifaceted. Higher GDP per capita and higher GDP growth often indicate greater consumption, potentially leading to increased imports and a current account deficit. Additionally, wealthier nations, with greater financial capacity, tend to engage in higher levels of both domestic and foreign investment, impacting the current account by potentially contributing to a trade deficit through increased imports for domestic investment and generating income through foreign investments.

The relationship is also influenced by savings behavior, economic structure, and cyclical factors, with economic downturns possibly improving the current account temporarily.

A higher old-age dependency ratio and an anticipated increase in this ratio positively impact the current account by fostering greater savings among the aging population. Conversely, a higher population growth rate, particularly driven by a younger demographic,

tends to worsen the current account by leading to lower savings and increased demand for imports among the younger population.

The positive correlation between the oil balance and the current account indicates that countries reliant on oil imports tend to have larger current account deficits, as the cost of oil imports significantly impacts trade balances, making them more vulnerable to fluctuations in oil prices.

3.2.4 Financial Soundness Index Computation

Given the methodological constraints necessitating parsimony in variable selection, we adopt a pragmatic approach to condense the multilateral dimensions of the financial sector's performance. We follow the Uniform Financial Rating System approach to build a composite indicator with regard to financial stability, making use of two approaches referred to as CAELS rating (Capital adequacy, Asset quality, Earnings, Liquidity and Sensitivity to market risk) and CAMELS (Capital adequacy, Asset quality, Earnings, Liquidity, Sensitivity to market risk, and Management)[1] as presented in Table 3A in the Appendix. These metrics denoting the robustness of the banking system encapsulate a comprehensive evaluation of the fundamental circumstances and risks factors influencing the stability of the banking sector. The metrics are constructed from five constituent sub-indices, each correspondingly representing the aforementioned dimensions characterizing the banking sector. The data for each ratio – for the five dimensions – are collected for each country at the bank sector level from the International Financial Statistics of the IMF.

[1] These approaches align with the recommendations of the ECB (2007) and the International Monetary Fund Compilation Guide 2006 on Financial Soundness Indicators and are also used by other studies such as Sere-Ejembi et al. (2014) and Cleary and Hebb (2016).

Most of the Financial Stability Index (FSI) series start from 2010, so for missing data before that year, we filled in gaps using data from central bank websites where available and then extrapolated the rest using auto-ARIMA processes (Hyndman & Athanasopoulos, 2018), followed by interpolation to convert the data into quarterly format. We have employed the Litterman interpolation techniques (Litterman, 1983) to convert annual data into quarterly data. More specifically, a high-frequency model is deployed, involving a linear framework augmented by ARI(1,1) disturbances, characterized by Markovian random walk dynamics. The estimation procedure is executed through the optimization of either maximum likelihood or weighted least squares criteria.

Initially, employing statistical methodologies, every indicator encompassed within these distinct categories undergoes a process of normalization onto a uniform scale, with a mean of zero and a standard deviation of one. By doing so, we circumvent any aggregation distortions stemming from variations in indicator means. The corresponding formula is presented as follows: $Z_t = \frac{X_t - \mu}{\sigma}$, where X_t stands for the value of indicators during the time frame t. The mean is represented by μ, while σ signifies the standard deviation. Next, all the normalized values from the correlated indicators, grouped within a single category, are converted into a distinct uncorrelated index, using a principal component analysis approach. These values are then standardized in accordance with the method illustrated in Equation (1). Subsequently, these computed sub-index values are adjusted to range between [0, 1] using an exponential transformation, described as [1 / (1 + exp(-Z*))]. The Financial Stability Index constructed using CAELS and CAMELS methods, is formulated by summing up the respective estimated exponentially transformed sub-indexes: $FSI_t = \sum_{j=1}^{6} \omega_j \sum_{1}^{n} Z_{i,j}^{*}$ where $\sum_{j=1}^{6} \omega_j = 1$.

The term Z* refers to the exponential transformation of the average normalized values for each indicator within the sub-index, forming part of the individual bank stability index. Interpretatively, the derived index serves as a comparative indicator. Specifically, an uptick in the index value for any given dimension suggests a reduction in risk for that dimension in the respective period when contrasted with other time frames.

4. Results

4.1 Macro-financial Effects of Climate Change

Figure 2 presents the empirical results[2]. Estimating the effects across multiple quantiles, allow us to understand the distributional impact of extreme weather events, identifying whether these shocks are more disruptive in certain economic conditions.

The output gap (y_gap) becomes lower in magnitude at higher quantiles, meaning that countries or periods already experiencing a significant negative output gap (i.e., economic contractions) see this gap go even further into negative territory due to climate shocks. In other words, for economies with larger negative output gaps, extreme weather events exacerbate these contractions, pushing output further below potential. This suggests that more vulnerable countries, already struggling with economic downturns, are hit harder by climate events.

Inflation exhibits asymmetric effects across the quantiles. Climate events tend to have a stronger impact on inflation variability at both the lower and upper quantiles. However, the effects are statistically significant only at the upper quantiles, suggesting that climate shocks are more likely to exacerbate inflation during periods of already high inflation. This indicates

[2] Statistically significant effects are indicated when the confidence intervals do not cross horizontal axis; otherwise, the effects are not significant.

that economies experiencing elevated inflation are more vulnerable to additional price volatility triggered by extreme weather events.

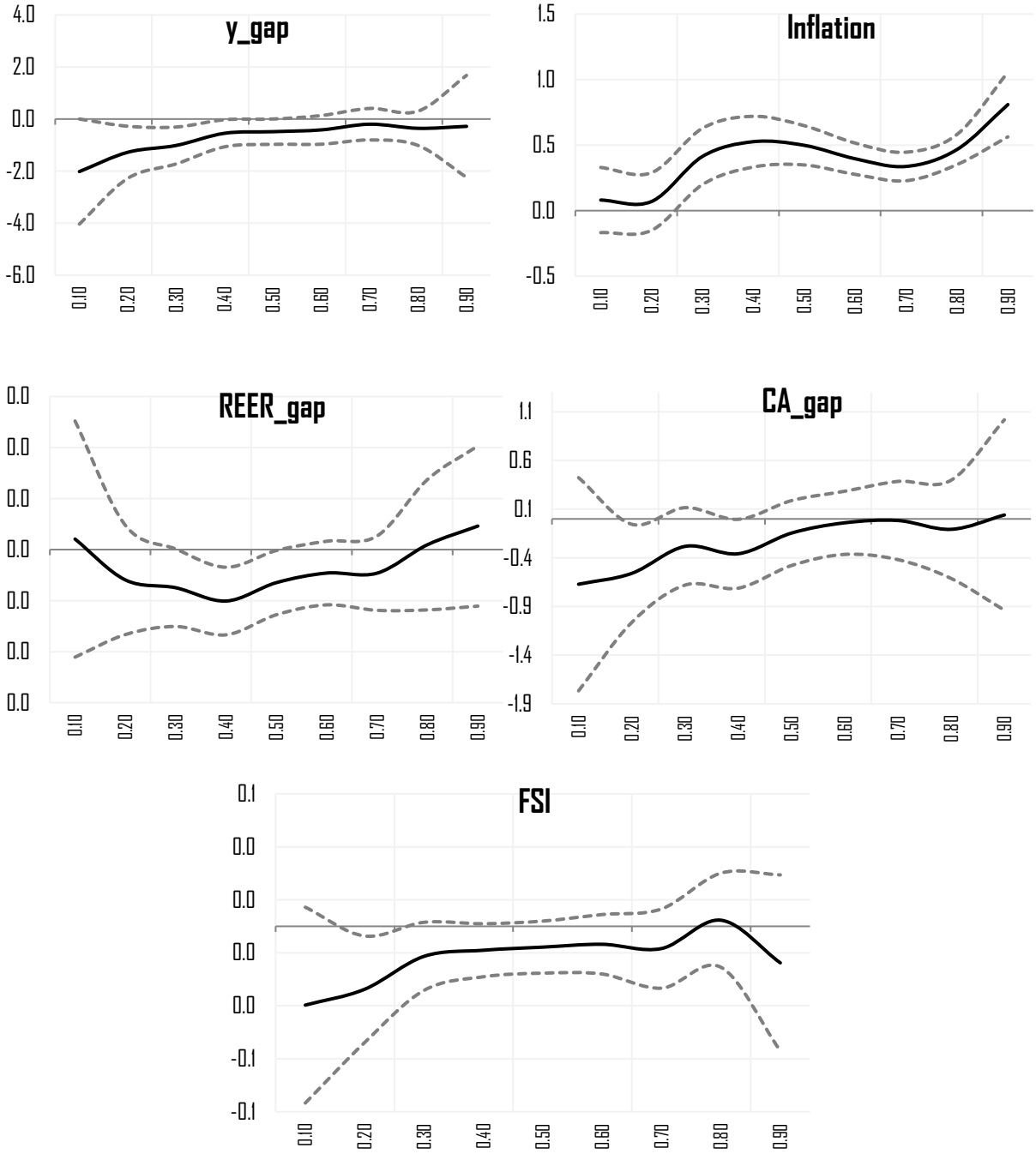

Figure 2. Estimates of macro-financial effects of climate change across different quantiles.
Source: Author's computations.

When it comes to external imbalances, the effects of climate shocks tend to be more moderate, with statistical significance observed at the 0.3; 0.4 and 0.5 quantiles, respectively

for the current account gap and REER gap measures. Climate shocks have a statistically significant effect on CA_gap at lower quantiles, where countries already face negative current account balances (deficits). The widening of the current account deficit following extreme weather events reflects the disruption of trade flows, increased reliance on imports, and reduced export revenues. This effect may be particularly concerning for economies with structural weaknesses, such as heavy reliance on climate-sensitive sectors like agriculture or tourism, limited diversification, and constrained fiscal capacity. At higher quantiles, where countries have positive CA_gap, the effects of climate shocks are smaller and statistically insignificant.

While the immediate effects of climate shocks are more pronounced in countries with existing external imbalances, underlying vulnerabilities may still pose risks even for economies with relatively stable external positions. This invites further investigation that could explore why some countries are more affected and whether specific characteristics (e.g., economic structure, reliance on certain industries, or levels of fiscal health) contribute to their heightened sensitivity to climate shocks.

The significant effects of climate shocks on financial imbalances at low quantiles indicate that these impacts are particularly pronounced for countries with lower levels of financial resilience or stability. Specifically, it suggests that for countries experiencing already high financial vulnerabilities, might face greater challenges in maintaining financial soundness, as climate shocks could disrupt their financial systems, affecting liquidity, credit availability, or asset values.

The findings so far suggest that climate shocks may exacerbate macrofinancial vulnerabilities across the CESEE region, and economies with existing financial weaknesses are particularly susceptible to the compounding effects of climate events.

4.2 Country-group Analysis

In the initial analysis, we examine the results across the full sample of CESEE countries, offering a comprehensive view of the region's macroeconomic and financial responses to extreme weather events. To delve deeper, this section breaks down the countries into three groups: Western Balkans non-EU countries[3], early EU entrants[4], and later EU entrants[5]. This division reflects key differences in macrofinancial stability, economic development, and institutional resilience of these countries.

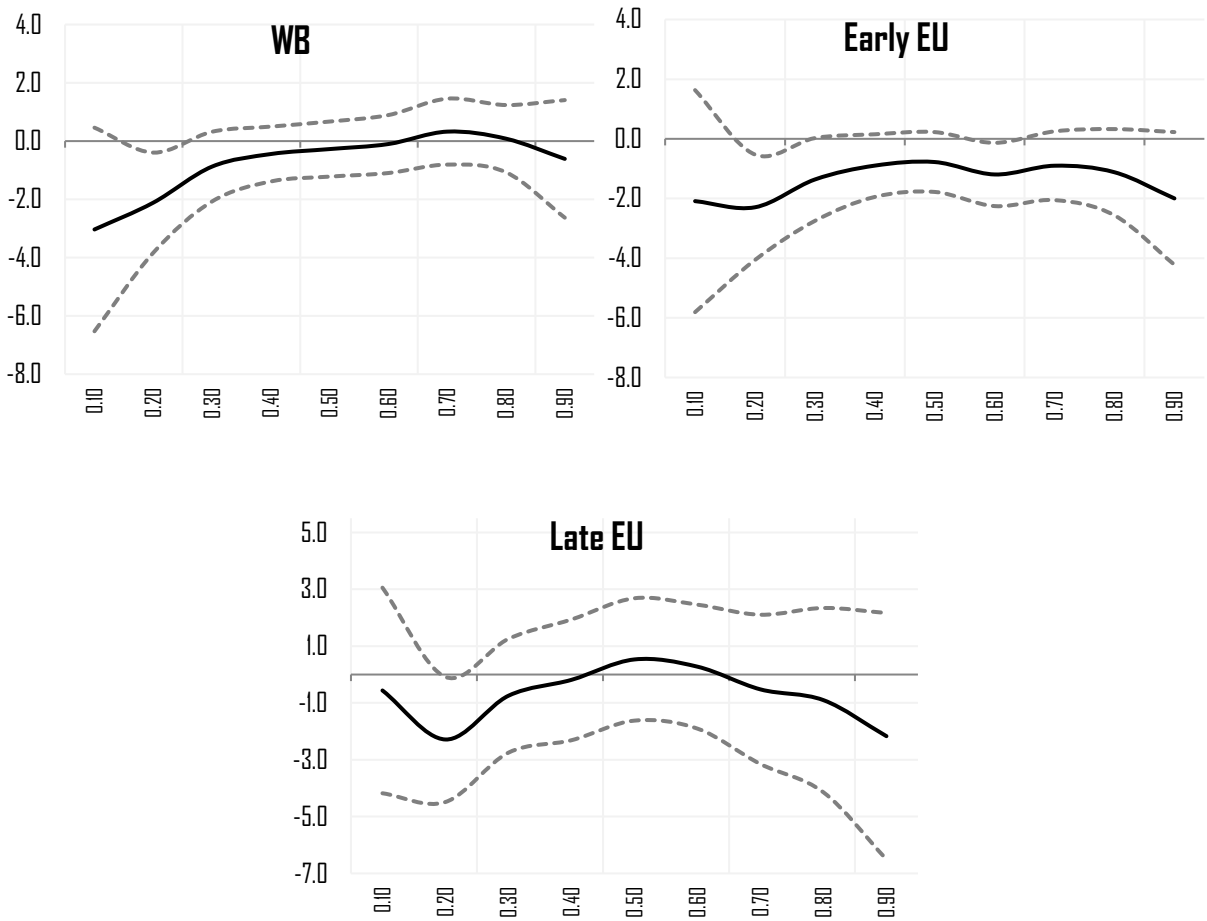

Figure 3. Country-group analysis of climate change effects on the output gap.
Source: Author's computations.

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[3] Albania, Bosnia and Herzegovina, North Macedonia, Montenegro, Serbia.

[4] Czech Republic, Estonia, Hungary, Latvia, Lithuania, Greece, Poland, Slovakia, Slovenia.

[5] Romania, Bulgaria, Croatia.

Our analysis begins by examining the output gap (y_gap) within each group, focusing on how climate shocks intensify economic contractions. In the Western Balkans non-EU countries, where economic diversification is often limited and structural constraints persist, climate shocks seem to deepen already negative output gaps, worsening economic downturns in vulnerable economies. In contrast, early EU entrants, with more established economic structures and policy frameworks, are likely to show greater resilience, though some vulnerabilities may surface in economies heavily reliant on climate-sensitive sectors like agriculture. Later EU entrants show a transitional pattern of resilience, with output gaps moderately affected by climate shocks.

This aligns with Burke, Hsiang, and Miguel (2015) who suggest that lower-income economies suffer more persistent economic contractions following climate shocks due to limited adaptation capacity. Our findings also support Cevik and Jalles (2024), who show that the adverse effects of extreme weather events on economic growth are significantly larger in developing economies, where structural weaknesses amplify economic downturns.

Next, we analyze inflation responses, focusing on how climate shocks influence price variability across different quantiles within each group.

In the Western Balkans, climate shocks have a stronger impact at higher quantiles, suggesting that inflationary effects intensify when price pressures are already elevated. This could be attributed to weaker monetary frameworks, higher exposure to climate-sensitive sectors such as agriculture and energy, and greater external dependencies. Early EU entrants exhibit a more gradual inflationary response across quantiles, which may reflect stronger institutional and monetary policy frameworks that help absorb shocks more effectively. In later EU entrants, inflationary effects of climate shocks seem to be slightly more pronounced under moderate price pressures, but appear more contained at higher levels, potentially due to

improving policy credibility and integration into broader EU economic mechanisms that help mitigate inflationary volatility.

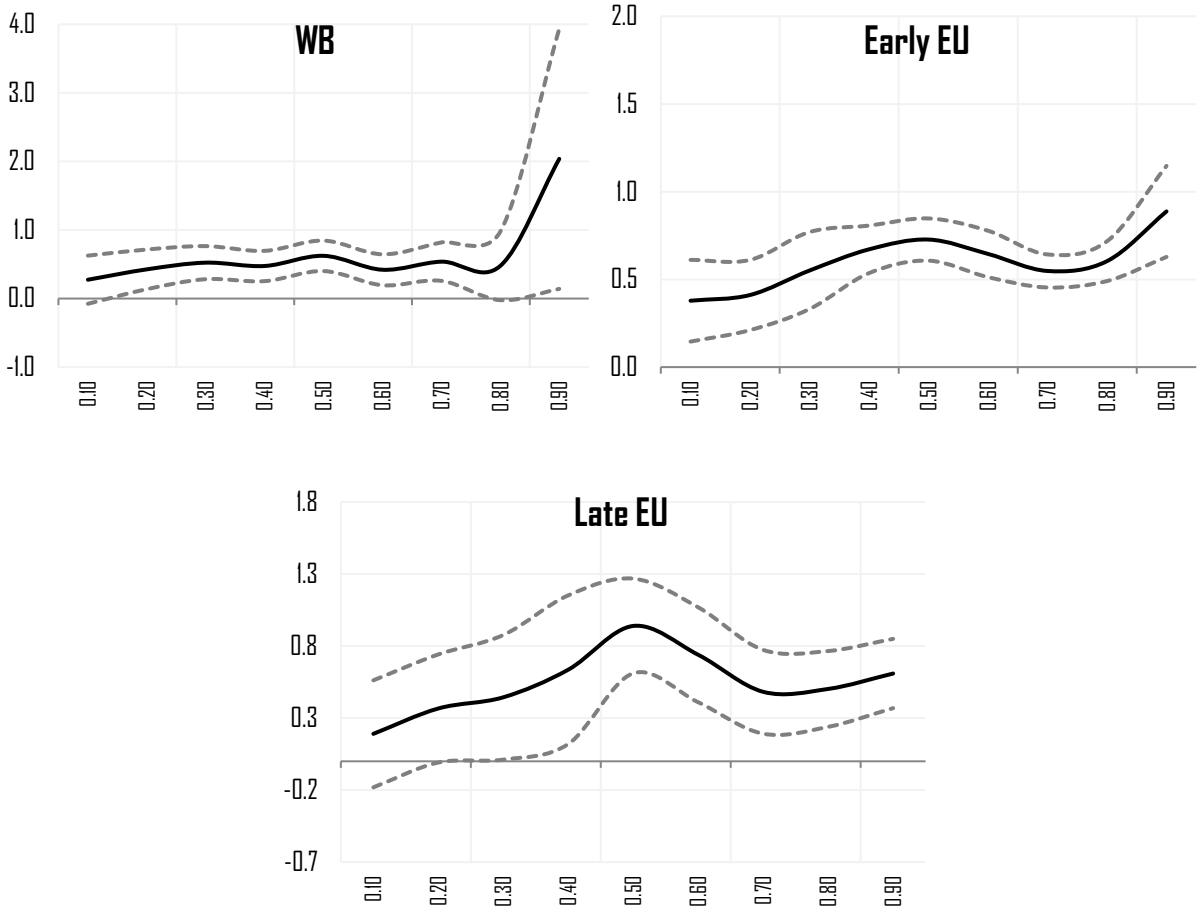

Figure 4. Country-group analysis of climate change effects on inflation.
Source: Author's computations.

These results are consistent with Kabundi et al. (2022), who show that extreme weather events, particularly droughts, lead to persistent inflationary effects, especially in developing economies where food prices constitute a large share of household expenditures. Faccia et al. (2021) further demonstrate that extreme temperatures drive short-term food price inflation, with stronger effects in emerging markets.

We then explore external imbalances by assessing the effects of climate shocks on the current account gap and real effective exchange rate (REER) gap for each group. The current

account gap in the Western Balkans displays a negative effect across quantiles, particularly pronounced and statistically significant in the lower quantiles.

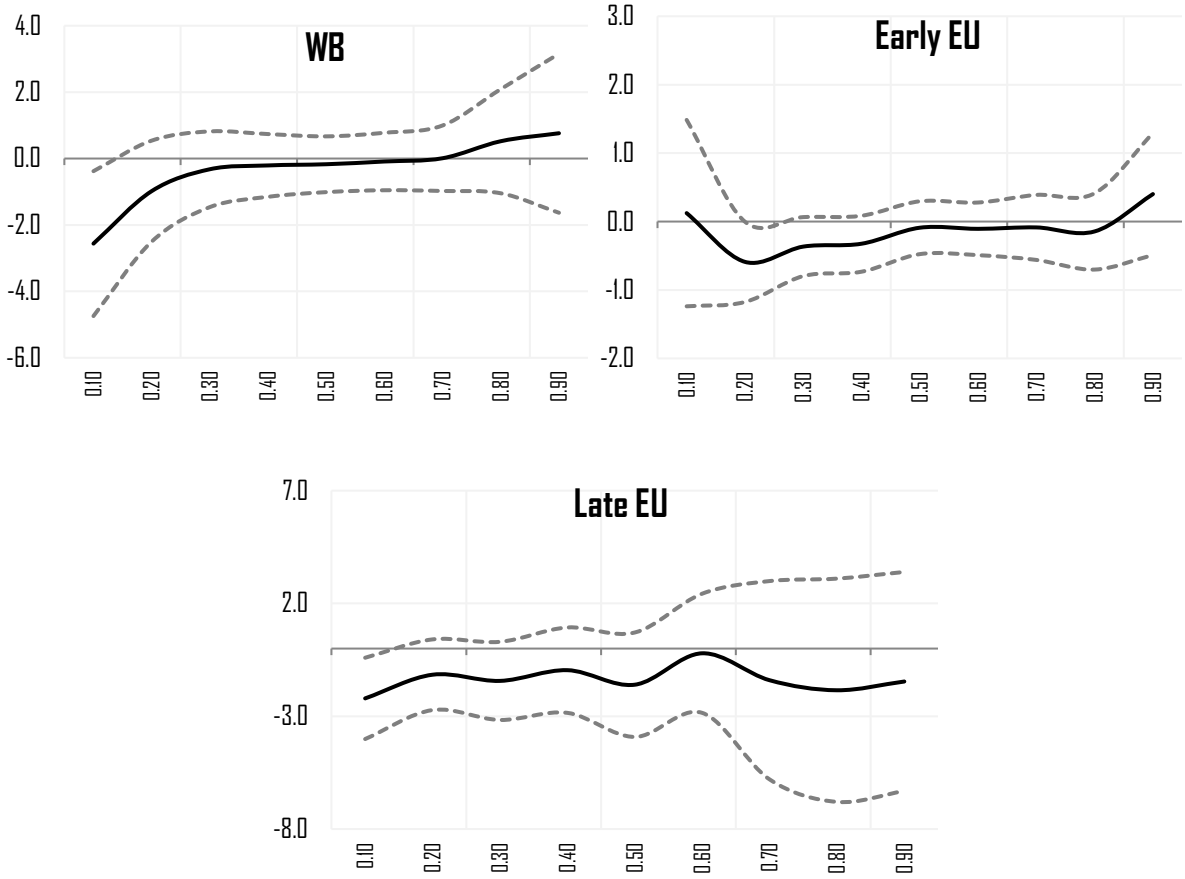

Figure 5. Country-group analysis of climate change effects on current account gap.
Source: Author's computations.

This suggests that climate shocks have asymmetric effects on external balances, widening current account deficits through increased import dependency, disrupted exports, and external financing constraints, while having little to no impact on countries with surpluses. This reinforces pre-existing imbalances, making deficit economies more vulnerable to climate-related shocks. The CA gap in early EU entrants shows a more muted response to climate shocks compared to the Western Balkans, possibly due to stronger trade diversification, better access to financial markets, or more effective policy buffers. The graph indicates a flatter trend across quantiles, with minor fluctuations. The CA gap in later EU entrants exhibits a higher decrease in lower quantiles, similar to the Western Balkans.

Figure 6 illustrates the impact of climate shocks on REER misalignment.

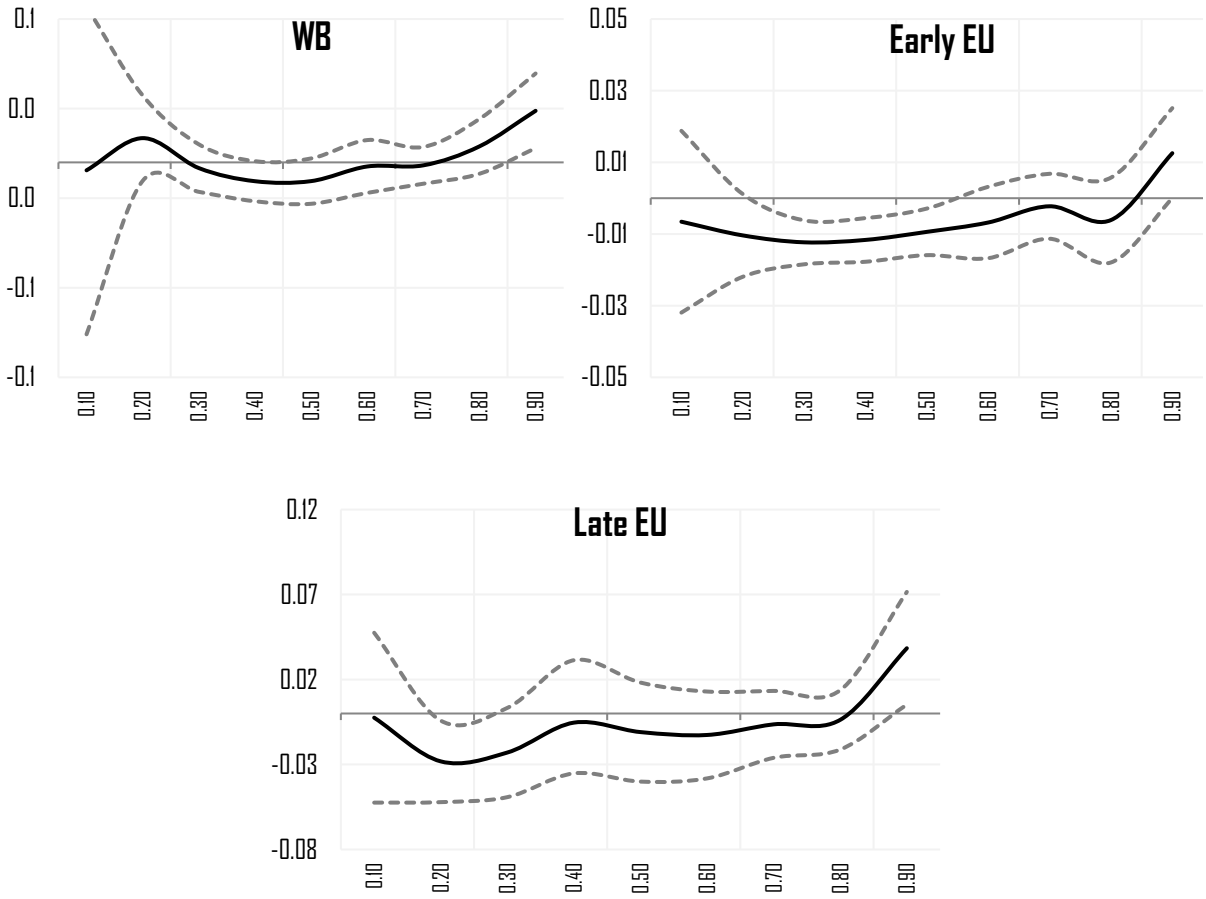

Figure 6. Country-group analysis of climate change effects on exchange rate.

Source: Author's computations.

The results indicate that climate shocks have asymmetric effects on REER gap. At lower quantiles, extreme weather events further lower the REER gap, deepening undervaluation when currencies are already misaligned downward. This suggests that for countries with initially undervalued exchange rates, climate shocks reinforce depreciation pressures, potentially increasing import costs and inflation. Conversely, at higher quantiles, where the REER gap is positive (indicating overvaluation), climate shocks push REER misalignment further upward, reducing price competitiveness and worsening trade deficits. These effects are most pronounced in economies with weaker financial buffers.

The results are in line with Jones and Olken (2010), Missirian and Schlenker (2017), Burke et al. (2015), and Schlenker and Osberghaus (2025), who find that climate change significantly impacts exports, with some studies highlighting stronger effects on poorer countries while richer economies remain largely unaffected.

Finally, we consider financial vulnerabilities, focusing on how climate shocks impact financial resilience across groups. The estimation results are presented in Figure 7.

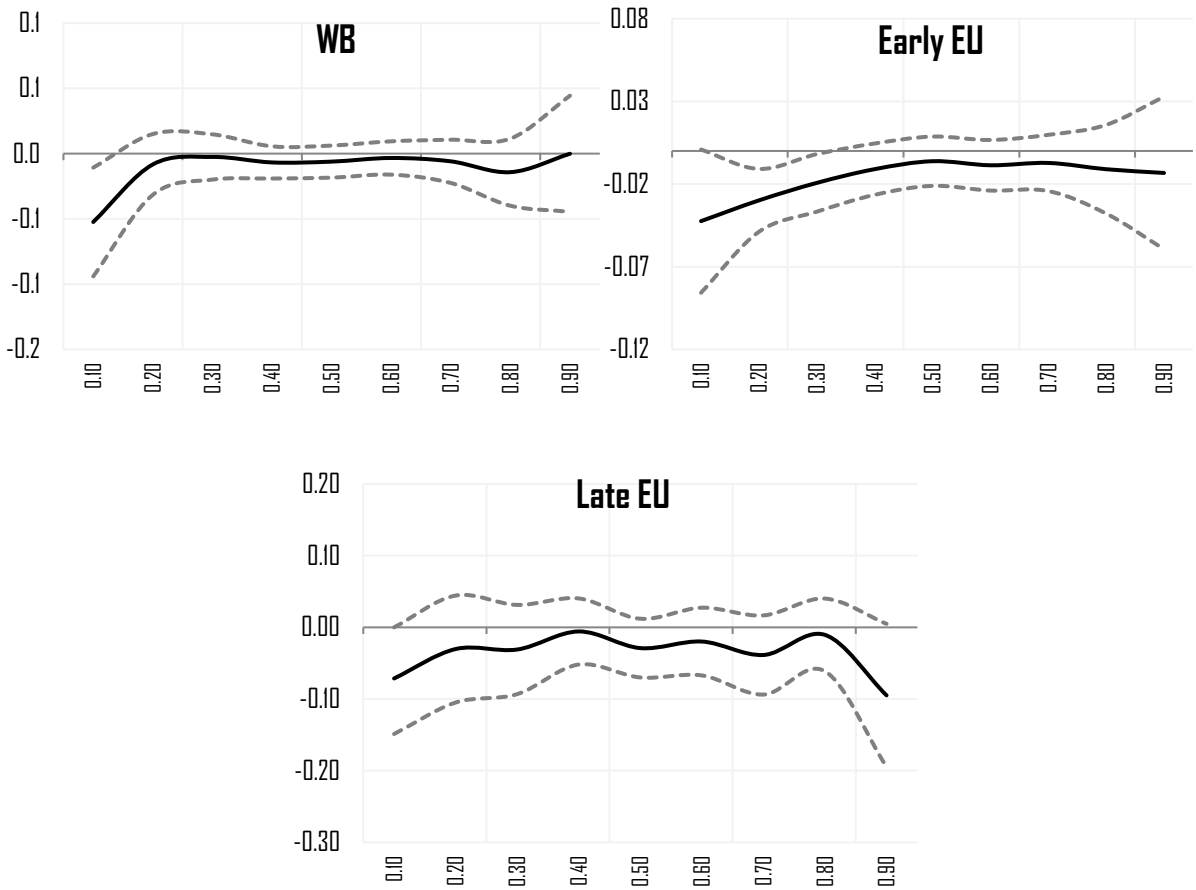

Figure 7. Country-group analysis of climate change effects on financial stability.
Source: Author's computations.

The Western Balkans non-EU countries are likely to exhibit pronounced financial impacts, especially where existing vulnerabilities are high, due to limited financial buffers and structural weaknesses. Early EU entrants, though generally more resilient, could experience sector-specific financial disruptions in industries heavily exposed to climate risks. Later EU entrants show intermediate resilience, with financial effects dependent on sectoral exposure

and their progress in implementing climate-adaptive policies. Our results align with Roncoroni et al. (2019), Flori et al. (2020), and Garbarino and Guin (2020), who find that climate shocks exacerbate financial vulnerabilities.

Based on the country group analysis, our findings indicate pronounced asymmetries in the effects of climate shocks on key macrofinancial indicators, with impacts varying across the Western Balkans, early EU entrants, and later EU entrant countries.

However, it is important to stress that assessing the effects of climate change, particularly its impact on macroeconomic and financial stability, poses significant challenges due to the complexity and uncertainty that characterize climate-related phenomena. The nonlinear nature of climate events complicates our understanding, as these events can have varying impacts depending on their intensity, frequency, and context. Additionally, the interconnectedness of global economic systems means that climate shocks can propagate through different sectors and geographies, creating a web of effects that is difficult to untangle. The presence of numerous feedback loops further complicates the precise quantification of the economic consequences of climate change, as changes in one area can lead to unforeseen repercussions in others.

This study represents an effort toward understanding the complex interactions between climate risks and economic variables in this region. However, it is important to acknowledge that this empirical analysis may have limitations that could hinder the full capture of the economic impact of climate risks stemming from extreme weather events. These limitations might lead to an underestimation of the overall assessed economic impact. One potential source of underestimation is the exclusion of catastrophic outcomes and significant phenomena, such as ecosystem degradation and collapse, which are challenging to incorporate into the assessment.

Moreover, the analysis may be subject to omitted variable bias if we fail to account for other factors that influence macroeconomic outcomes. These factors can include technological advancements that enhance resilience to climate shocks, policy changes aimed at mitigating climate risks, and broader global economic conditions that interact with climate variables. Such omissions may distort the overall assessment, suggesting that the impacts of climate change are less severe than they may actually be. Acknowledging these limitations is essential for contextualizing our findings and guiding future research in this important area.

5. Final Remarks and Policy Implications

This study contributes to the literature by providing a comprehensive analysis of the asymmetric and heterogeneous effects of extreme weather events on macroeconomic imbalances in CESEE countries. Using panel quantile regression analysis, we examine how climate shocks affect key macroeconomic and financial indicators, offering insights into their distributional impact across economies with varying levels of vulnerability - an aspect often overlooked in existing research.

Our findings indicate that extreme weather events significantly undermine internal macroeconomic stability, particularly in countries already grappling with high imbalances. This underscores the heightened sensitivity of economic output and prices to climate shocks, suggesting that pre-existing economic weaknesses can exacerbate the adverse effects of such shocks. In terms of external imbalances, climate shocks disrupt trade and investment flows, with the effects being more pronounced in countries with larger initial current account deficits.

Moreover, the findings imply that while financial stability may be somewhat insulated from extreme weather shocks due to robust regulatory frameworks and risk management

practices, countries with high economic vulnerabilities are still likely to encounter financial challenges in the wake of climate-related disruptions.

Climate change creates additional trade-offs for policymakers, complicating policy responses and increasing uncertainties. Mitigating and adapting to climate change requires substantial changes to the economy, which imply significant policy intervention, investment, and innovation (Gillingham and Stock, 2018). A vast literature suggests that environmental policies and investments in climate mitigation can have positive effects on the economy (Metcalf and Stock, 2020; Batini et al., 2021; Sokolov-Mladenović et al., 2016; Wong et al., 2013). However, to maximize these benefits, the combination of environmental policies and technological innovation should be carefully planned.

Several policy actions can be derived by the empirical analysis to address the macro-financial imbalances exacerbated by extreme weather events. Our findings support the need for a flexible approach to monetary policy (see for instance Cantelmo et al., 2024), as extreme weather events create supply-side shocks that reduce output and increase inflationary pressures. Rigid inflation-targeting frameworks, as we observed in some economies, may amplify economic volatility during such shocks. A more flexible approach, allowing temporary deviations from inflation targets while maintaining overall policy credibility, would be more appropriate, especially for developing economies highly exposed to climate risks.

Our results further emphasize the need to integrate climate risks into financial regulation. We find that economies with weaker financial systems are more vulnerable to the impacts of climate shocks. This aligns with Monasterolo (2020), who advocates for incorporating climate-related financial risks into capital requirements, stress testing, and disclosure frameworks. Strengthening these macroprudential regulations will ensure financial stability in the face of increasing climate risks.

In terms of fiscal policy, targeted interventions, such as investment in climate-resilient infrastructure and financial support for vulnerable sectors, are crucial to addressing the structural vulnerabilities amplified by climate shocks. Additionally, a balanced policy mix, including green investment incentives and improved climate stress testing, is needed to reduce economic vulnerabilities. Ciccarelli and Marotta (2024) advocate for structural reforms, including investments in renewable energy and disaster resilience, to build more resilient economies that can withstand climate-related shocks.

Finally, Diluiso et al. (2025) underscores the importance of a smooth and coordinated transition to a low-carbon economy. Delayed or uncoordinated climate policies risk increasing inflation volatility and financial instability. Gradual, well-communicated climate policies, coupled with coordinated fiscal and monetary policies, are essential for ensuring long-term economic stability, particularly in economies with weaker financial buffers.

Critically, the implications for optimal climate policies and mitigation pathways are considerable if the effect of weather shocks is persistent with permanently lower levels of GDP or even lower GDP growth rates (Moyer et al., 2014; Moore and Diaz, 2015; Ricke et al., 2018; Ueckerdt et al., 2019).

Nevertheless, further research is needed to better understand the dynamics and potential systemic risks associated with climate change. An examination of the differential effects of various types of extreme weather events - such as floods, droughts, and heatwaves -on specific sectors of the economy would provide valuable insights into sectoral vulnerabilities and resilience. Conducting cross-regional comparisons with other vulnerable economies could enhance the generalizability of findings and promote collaborative approaches to climate risk management. Investigating the role of supply chain disruptions, changes in investor sentiment, and shifts in consumer behavior following weather shocks, could also be valuable to explore

the underlying channels through which extreme weather events may indirectly influence external imbalances and financial stability.

Given the heightened vulnerability of economies with existing imbalances to extreme weather shocks, it is imperative to adopt proactive and comprehensive strategies that integrate climate risk assessments into economic planning and policymaking. Policymakers should prioritize the development and implementation of adaptive measures aimed at enhancing resilience in climate-sensitive sectors, such as agriculture and tourism, and promoting sustainable economic development. This includes investing in sustainable infrastructure, promoting diversification of the economy, and strengthening social safety nets to support affected populations.

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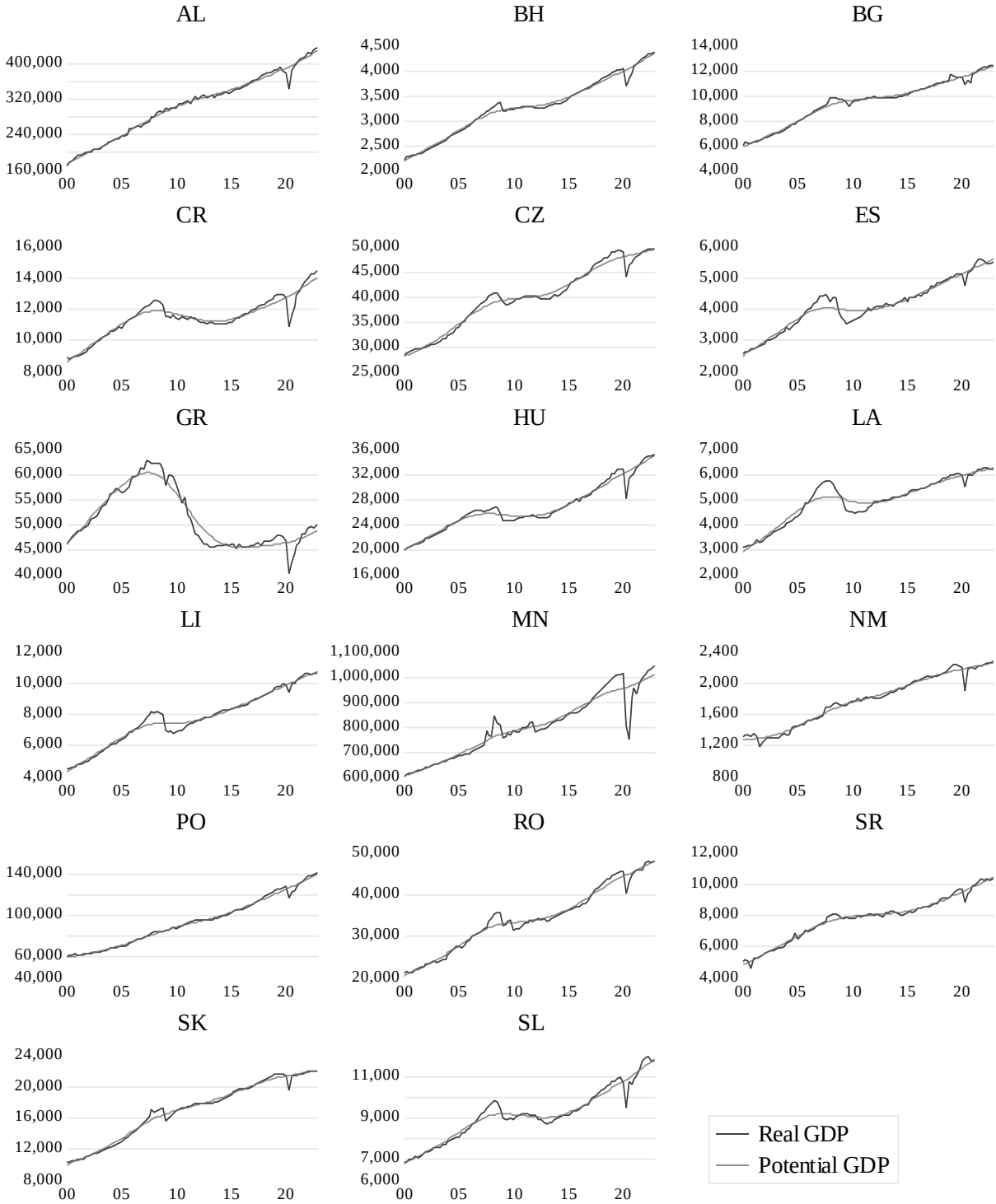
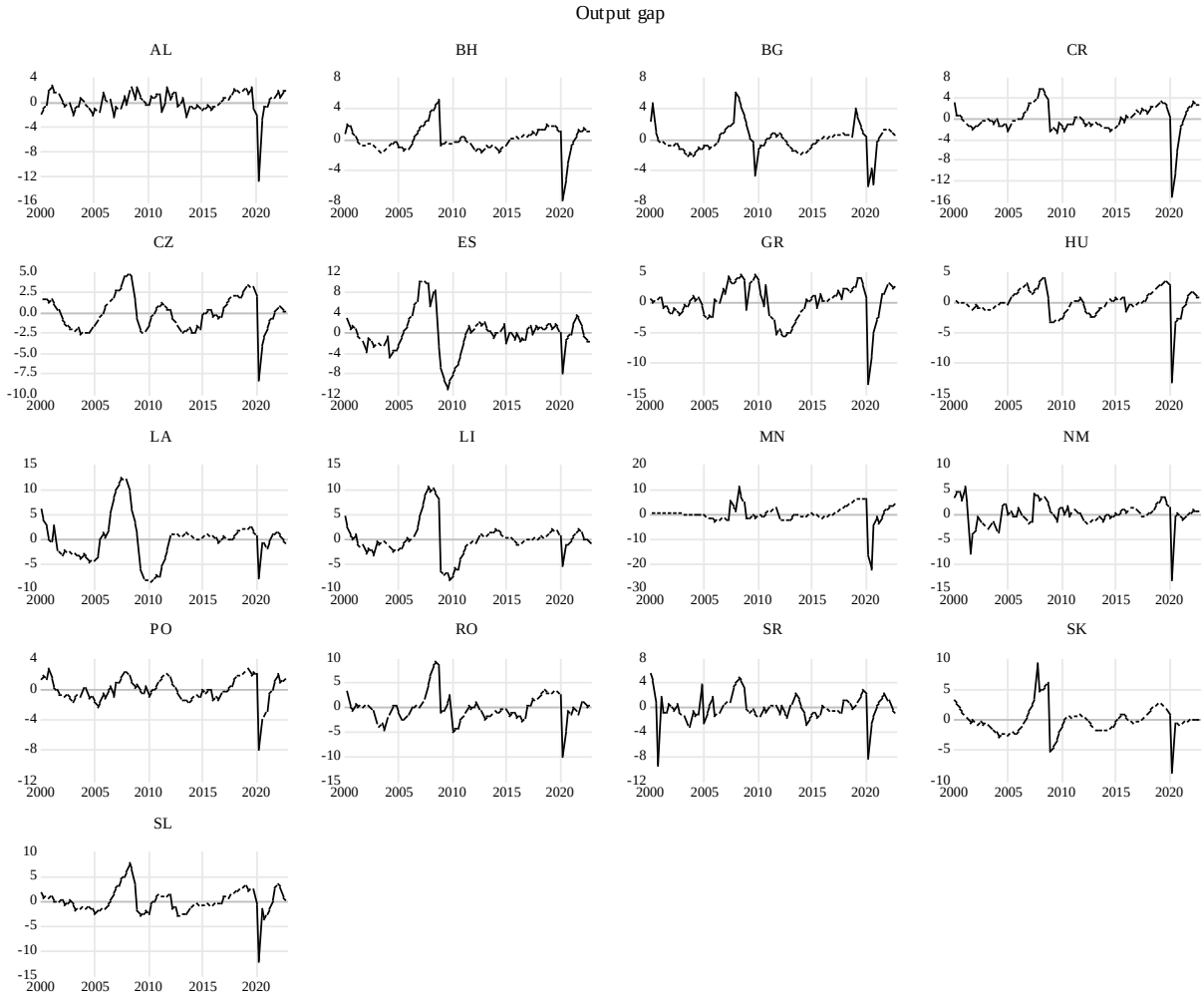
Appendix

Figure 1A. Real GDP vs potential GDP



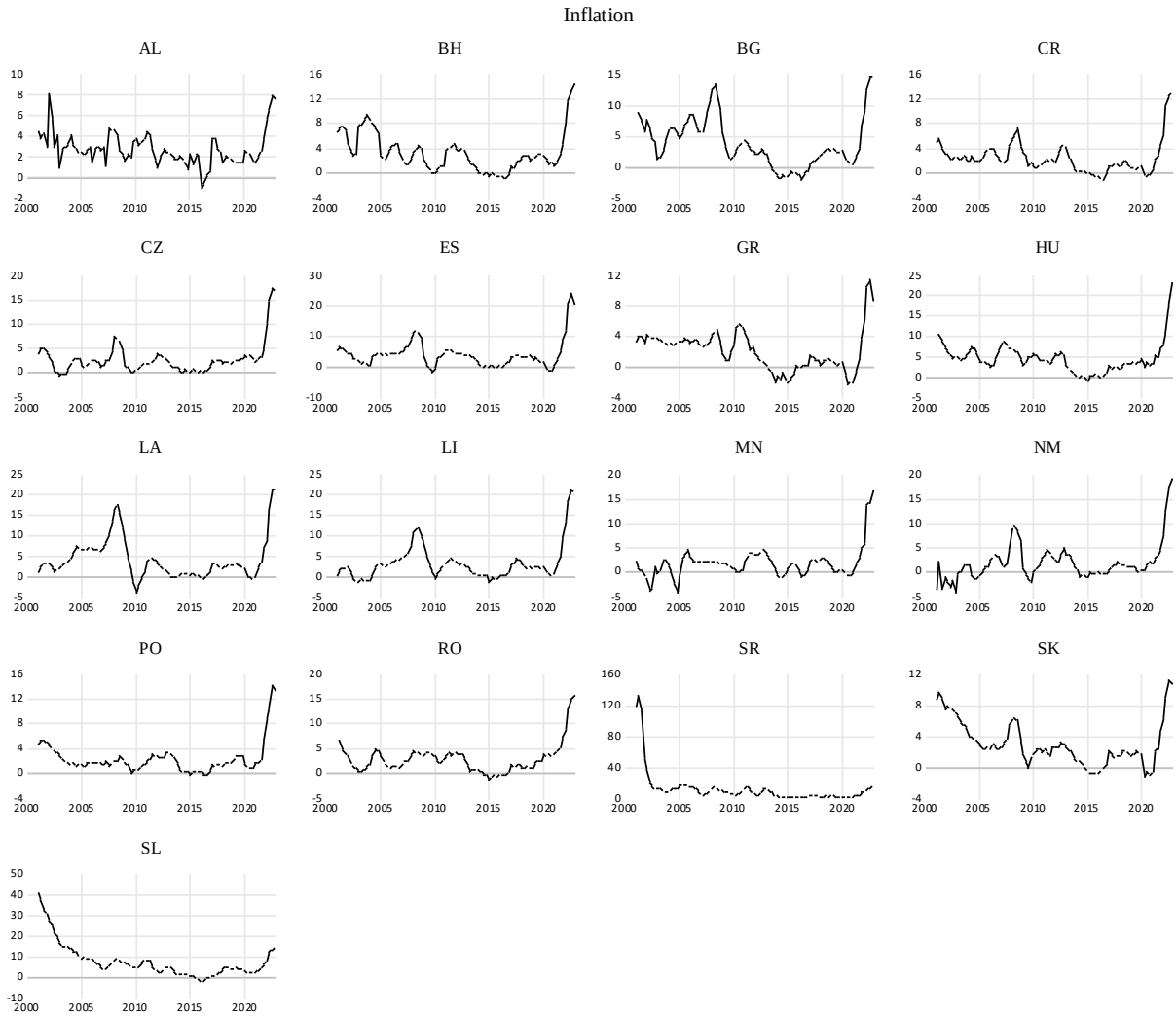
Legend: AL - Albania, BH - Bosnia and Herzegovina, BG - Bulgaria, CR - Croatia, CZ - Czech Republic, ES - Estonia, HU - Hungary, LA - Latvia, LI - Lithuania, MN - Montenegro, NM - North Macedonia, PO - Poland, RO - Romania, SR - Serbia, SK - Slovak Republic, SL - Slovenia

Figure 2A. Output gap



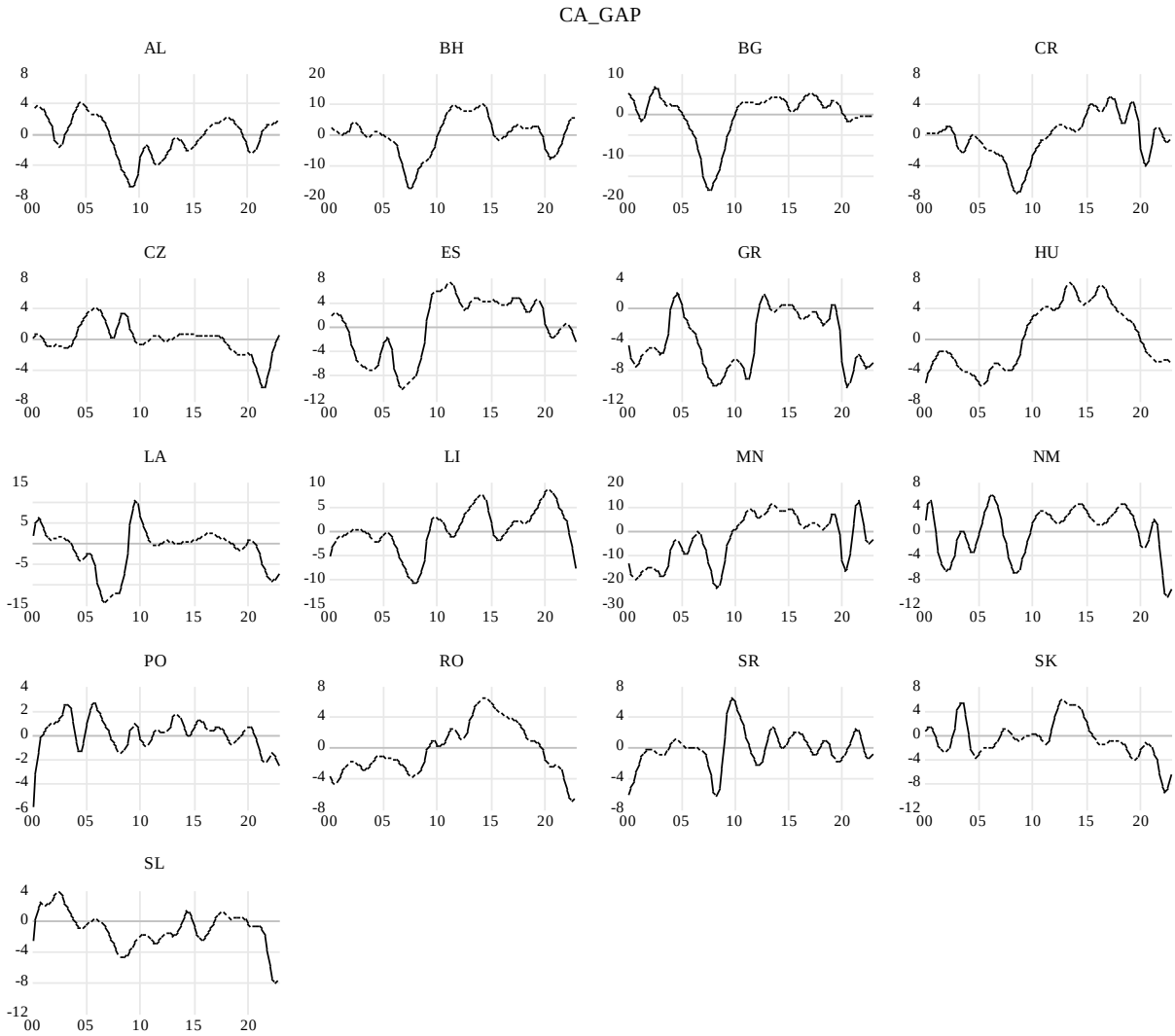
Legend: AL - Albania, BH - Bosnia and Herzegovina, BG - Bulgaria, CR - Croatia, CZ - Czech Republic, ES - Estonia, HU - Hungary, LA - Latvia, LI - Lithuania, MN - Montenegro, NM - North Macedonia, PO - Poland, RO - Romania, SR - Serbia, SK - Slovak Republic, SL - Slovenia

Figure 3A. Inflation



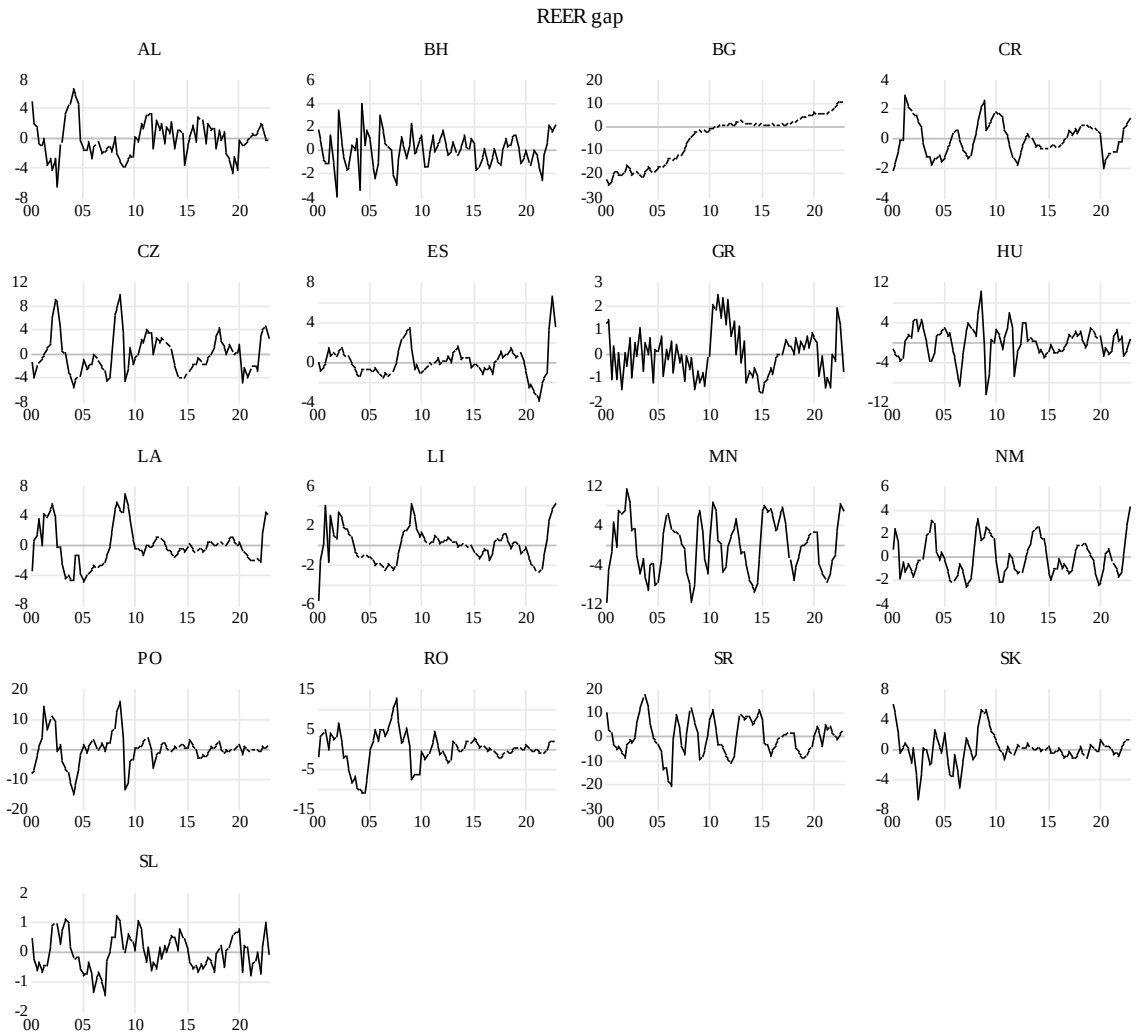
Legend: AL - Albania, BH - Bosnia and Herzegovina, BG - Bulgaria, CR - Croatia, CZ - Czech Republic, ES - Estonia, HU - Hungary, LA - Latvia, LI - Lithuania, MN - Montenegro, NM - North Macedonia, PO - Poland, RO - Romania, SR - Serbia, SK - Slovak Republic, SL - Slovenia

Figure 4A. Current account gap



Legend: AL - Albania, BH - Bosnia and Herzegovina, BG - Bulgaria, CR - Croatia, CZ - Czech Republic, ES - Estonia, HU - Hungary, LA - Latvia, LI - Lithuania, MN - Montenegro, NM - North Macedonia, PO - Poland, RO - Romania, SR - Serbia, SK - Slovak Republic, SL - Slovenia

Figure 5A. REER misalignments



Legend: AL - Albania, BH - Bosnia and Herzegovina, BG - Bulgaria, CR - Croatia, CZ - Czech Republic, ES - Estonia, HU - Hungary, LA - Latvia, LI - Lithuania, MN - Montenegro, NM - North Macedonia, PO - Poland, RO - Romania, SR - Serbia, SK - Slovak Republic, SL - Slovenia

Figure 6A. Interest spread

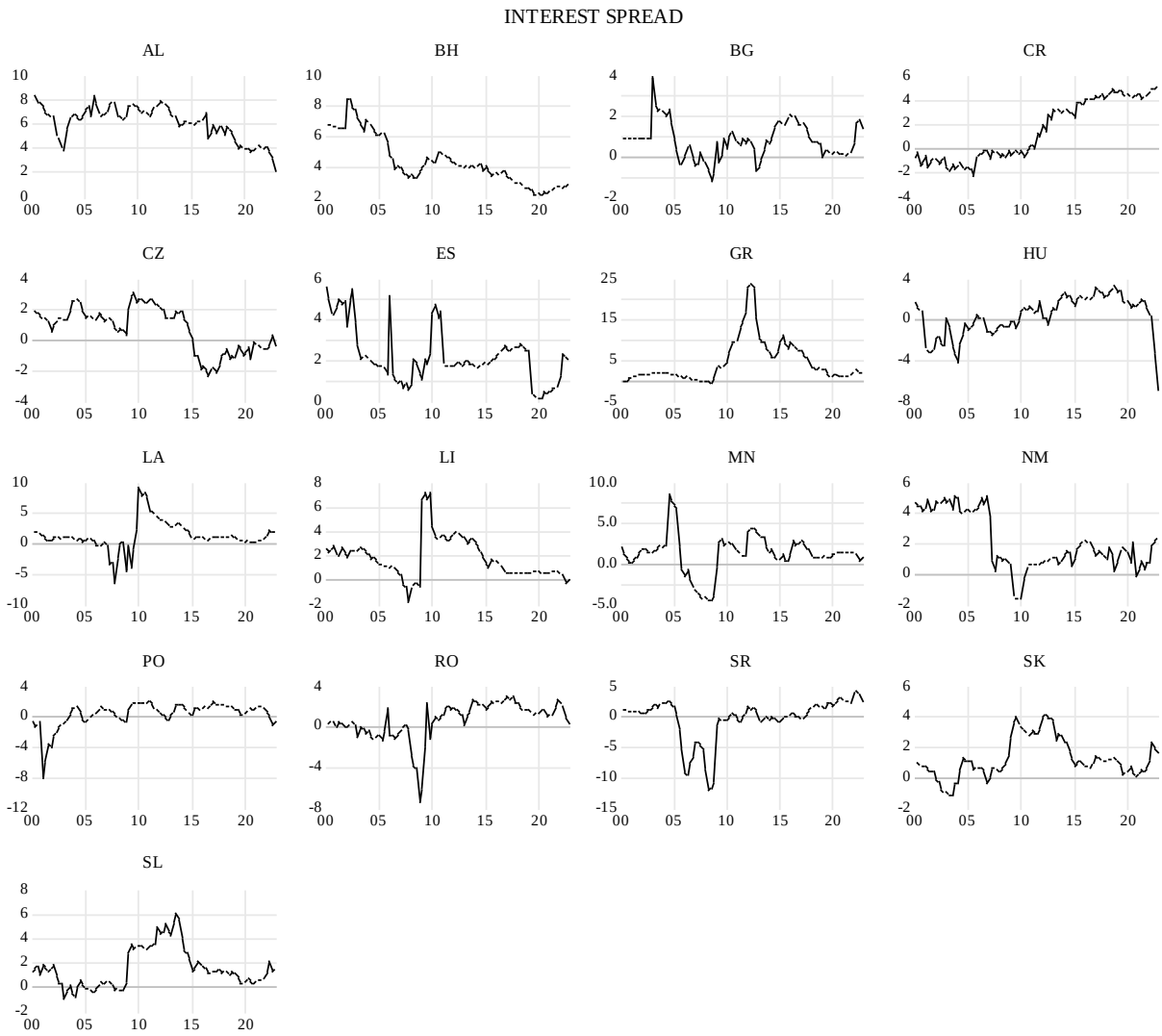


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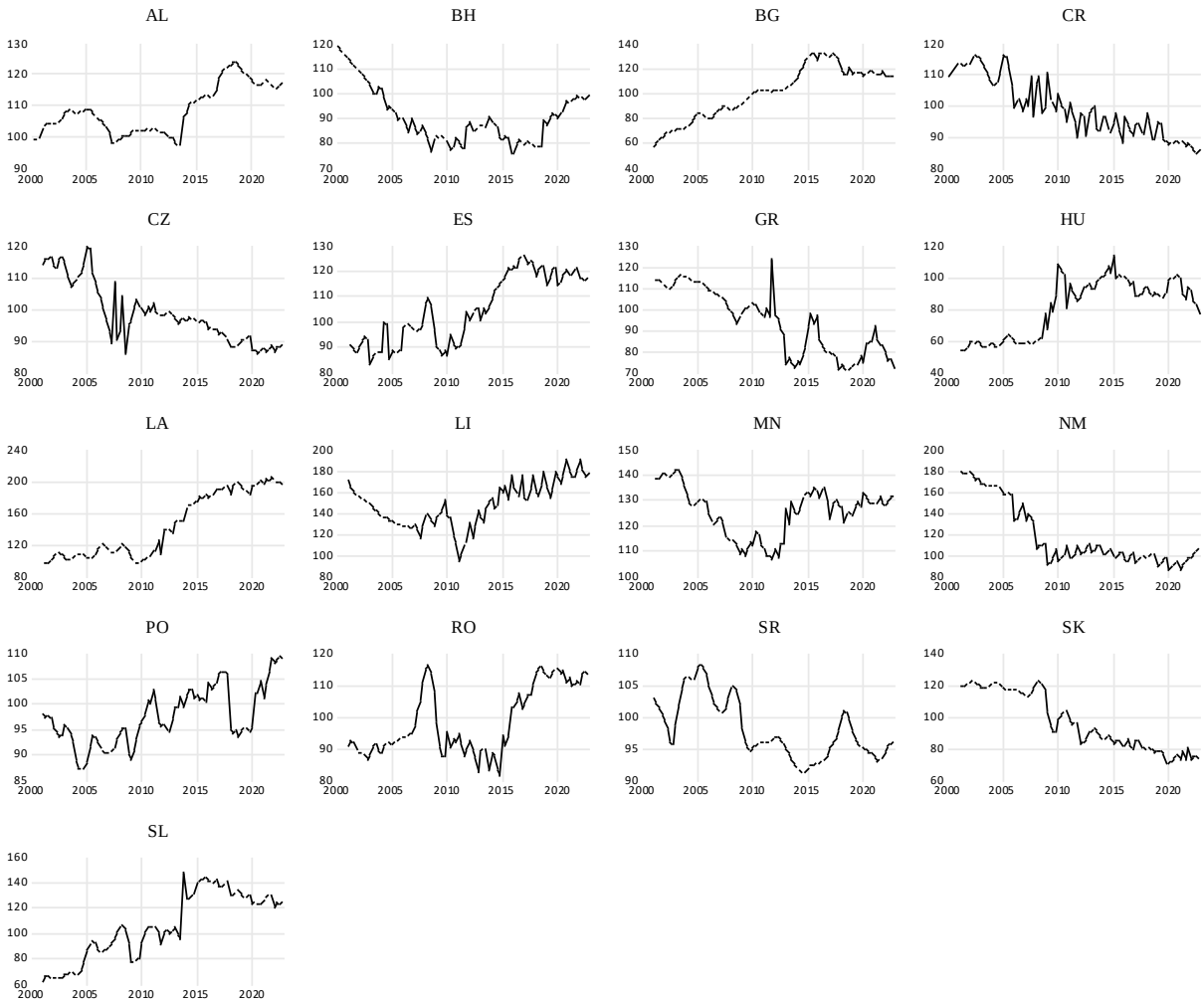
Figure 7A. Financial Soundness Index



Legend: AL - Albania, BH - Bosnia and Herzegovina, BG - Bulgaria, CR - Croatia, CZ - Czech Republic, ES - Estonia, HU - Hungary, LA - Latvia, LI - Lithuania, MN - Montenegro, NM - North Macedonia, PO - Poland, RO - Romania, SR - Serbia, SK - Slovak Republic, SL - Slovenia

Table 1A. Data description for the panel quantile regression.

Indicator	**Source**	**Label**	**Description**
E3CI	IFAB	e3ci	Current account balance in million USD to GDP in current USD ratio
Output gap	Eurostat and WEO Database (IMF) OECD Economic Outlook, IMF World Economic Outlook, National Central Banks, and Statistical Offices	y_gap	Calculated as the percentage difference between actual GDP and potential GDP. Potential GDP is estimated using HP filter.
Inflation	Eurostat, National Statistical Offices, World Bank, IMF WEO	inflation	Expressed as the percentage change in the natural log of the Consumer Price Index (CPI), seasonally adjusted
Current account GDP ratio gap	IMF Balance of Payments Statistics, National Central Banks; Updated and extended version of dataset constructed by Lane and Milesi-Ferretti (2007), "The External Wealth of Nations Database"	ca_gdp	Difference between the observed current account and its estimated equilibrium value using economic fundamentals.
REER misalignments	IMF International Financial Statistics, National Central Banks	reer_gap	REER (2010=100), Gap between the actual real effective exchange rate (REER) and its estimated equilibrium level using HP filter
Interest spread	IMF International Financial Statistics	spread	Difference between the average lending rate and the average deposit rate.
Financial Soundness Index	IMF Financial Statistics; extrapolation of the existing series before 2010	fsi	Composite index including capital adequacy, asset quality, management quality, earnings, liquidity, and sensitivity (CAELS/CAMELS methods)

Table 2A. Data description for the CA and REER norm estimation.

Indicator	**Source**	**Label**	**Description**
CA balance to GDP	WEO Database (IMF)	ca_gdp	Current account balance in million USD to GDP in current USD ratio
Real Effective Exchange Rate	Eurostat and WEO Database (IMF)	reer	REER (2010=100), CPI as a deflator
Fiscal balance to GDP ratio	IMF WEO	fiscal_gdp	General government revenue minus expenditure to GDP
Net foreign asset to GDP ratio (t-1)	Updated and extended version of dataset constructed by Lane and Milesi-Ferretti (2007), "The External Wealth of Nations Database"	nfa_gdp	The first lag of net foreign assets in millions of current US dollars to nominal GDP ratio
Level of PPP-adjusted GDP per capita	IMF WEO	gdp_cap	GDP per capita, PPP (constant 2005 international $)
GDP growth	IMF WEO	gdp_growth	Real GDP growth (annual)
Old-age dependency ratio	United Nations, Department of Economic and Social Affairs, Population Division (2022). World Population Prospects 2022, Online Edition.	old_dep	Population over 65y to population between 15-65y: ratio [65+ / 15-64] (%)
The aging rate	United Nations, Department of Economic and Social Affairs, Population Division (2022). World Population Prospects 2022, Online Edition.	ageing	The expected change in the old-age dependency ratio in the future (constructed as the difference between the age dependency ratio in year *t+20* and the same ratio in year *t)*
Population growth rate	WDI (the World Bank)	pop	Population growth (annual %)
M2 to GDP ratio	WDI, OECD Database	m2_gdp	Monetary aggregate M2 as a ratio of GDP (%) as a proxy of financial deepening
Openness	WDI, Eurostat	open	Exports plus imports of goods and services to GDP ratio
Terms of trade	WDI, Eurostat	tot	
Oil balance	Eurostat	oil_balance	Oil exports minus oil imports to nominal GDP ratio

Countries: Albania, Bulgaria, Bosnia-Herzegovina, Croatia, Czech Republic, Estonia, Greece, Hungary, Latvia, Lithuania, Montenegro, North Macedonia, Poland, Romania, Serbia, Slovak Republic and Slovenia.

Table 3A. Indicators used for the construction of the Financial Soundness Indicator.

Category	Indicator
(C)apital Adequacy	Capital Adequacy Ratio
	Core Capital/Total Asset
	Equity/Total Asset
	Asset growth
	Equity Growth
	Fixed Asset/Regulatory Capital
	ROE
	Non-Performing Loan (net)/Regulatory Capital
(A)sset Quality	Non-Performing Loan (net)/Total Loan (net)
	Total Loans (net)/Total Assets
	Growth of Loan Portfolio
	Credit Loss (Gross)/Total Loan (Gross)
	Large Risks (the number of beneficiaries over rate)
	Provisions for Loan Loss Coverage/Non-Performing Loans (gross)
(M)anagement	Income/cost
	Personnel expenses/total expenditure
	Personnel expenses/Non-interest income
	Interest expenditure/total deposits
	(Interest income - Interest expenditure)/Personnel Expenses
	Net Interest Profit/Total Assets
	Non-interest income/ Total income
(E)arnings	ROA
	The interest income growth
	Interest income/Total Income
	Net Interest Margin
	Efficiency Ratio
	Interest Revenue (Net)/Operating Revenues (Gross)
	Dividend/Income (Net)
	The growth of net interest income
	Liquid Assets/Total Assets
(L)iquidity	Net Loans/Deposits
	Assets – Passive with a maturity of three months/Total Assets that provide profits
(S)ensitivity to Market Risk	Asset – Passive sensitive to interest rate with a maturity up to 3 months/Total Assets that Provide Profit
	Asset – Passive sensitive to interest rate with a maturity up to 12 months/Total Assets that Provide Profit
	Net Open Position in foreign currency

Source: Sectoral Balance Sheet of Deposit Money Banks

Table 4A. Stationarity test results (Pesaran - CIPS).

	LEVEL		FIRST DIFFERENCE	
	INTERCEPT	INTERCEPT AND TREND	INTERCEPT	INTERCEPT AND TREND
Y_GAP	-3.773***	-3.744***	-6.517***	-6.470***
INFLATION	-2.930***	-3.154***	-5.161***	-5.248***
CA_GAP	-1.598	-1.825	-3.873***	-4.030***
REER_GAP	-3.195***	-4.157***	-4.794***	-4.787***
FSI	-1.777	-2.847	-8.044***	-8.038***
E3CI	-7.329***	-7.129***	-8.176***	-7.814***

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