MEASURING MACRO-ECONOMIC RESILIENCE: A SIMPLE COMPOSITE INDICATOR FOR THE WESTERN BALKANS

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Abstract

Many economic phenomena in economics and social sciences are measured using composite indicators that are weighted averages of single time-series variables. In a decade of complex changes in national economic systems owing to various shocks, developing an indicator that provides a more nuanced and accurate representation of the country's resistance to economic shocks is pivotal. Using data from six Western Balkan economies (Albania, Bosnia and Herzegovina, North Macedonia, Montenegro, and UNMIK Kosovo*) over the period 20002023, we construct a simple composite indicator of macroeconomic resilience to evaluate its temporal evolution empirically. Our index captures three unique dimensions: absorptive, adaptive, and transformative.

Our findings reveal that even though all countries have become more resilient to economic, social, and political shocks, the pace of improvement varies, widening the performance gap between the top and bottom countries in this region. In particular, Montenegro and Serbia are presented as the regional leaders in building macroeconomic resilience. In contrast, UNMIK Kosovo[27]* encounter the most notable challenges in the region.

Additionally, future research should examine the data structure used in the present study. In particular, it should underscore the use of multiway Principal Component Analysis (PCA), where we have three dimensions: countries, years, and variables, because the standard PCA approach is typically applied cross-sectional datasets and does not fully exploit the multidimensional structure of panel data. Ultimately, the relevance of a composite indicator of macroeconomic resilience extends beyond the academic domain to encompass practical implications for policymakers in their decision-making.

Keywords: economic resilience, shocks, composite indicator, Western Balkans

1. INTRODUCTION

The concept of economic resilience has gained considerable attention over the past two decades, considering various shocks: financial, energy, health, geopolitical, and climate that countries experienced. Some economies recover quickly and return to their pre-shock growth trajectories. Understanding this phenomenon has been one of the most challenging questions in macroeconomics. Even though vulnerability to such shocks is often unavoidable, the capacity to withstand, absorb, adapt to, and recover from disruptions determines whether an economy merely survives or undergoes a successful transformation in the aftermath.

Two recent global shocks can vividly illustrate the importance of macroeconomic resilience. The 2008 Global Financial Crisis revealed major structural vulnerabilities in many advanced and emerging economies. The 2008 crisis unearthed the fragility of highly leveraged financial systems; resilience measurement after this crisis shifted attention to stress testing banks, systemic risk indicators, and capital adequacy (see Haldane and May, 2011; Rose and Liao, 2005). Some economies — Germany, Poland, and the Nordic countries — absorbed the blow and progressed relatively quickly. Others, particularly in Southern Europe, spent most of the decade trying to recover, with unemployment rates that remained socially and politically damaging long after GDP had technically stabilised (Rose, 2009; Martin, 2012). This evidence suggests that resilience largely reflects pre-existing structural characteristics rather than short-term crisis responses. Likewise, the COVID-19 pandemic provided a new stress test for worldwide economic systems. The pandemic was extraordinary as an economic shock because it hit supply, demand, and public institutions simultaneously. Even though the initial shock caused a historic contraction in real output and employment, recovery paths varied substantially across countries. Countries with stronger institutions, digital infrastructures, and practical policy responses, including rapid fiscal and monetary support, demonstrated greater adaptive capacity and resilience (OECD, 2021; IMF, 2021). Estonia and Finland are two countries that, thanks to strong digital economies and effective public health responses, were able to cushion economic shocks and sustain business continuity more effectively than those with weak institutions.

The Western Balkan economies are particularly exposed to external shocks due to their structural characteristics and ongoing institutional transitions. These

[27] This designation is without prejudice to positions on status and is in line with UNSCR 1244 and the ICJ Opinion on the Kosovo* declaration of independence.
*Added by the Editorial Board and applies throughout the document.

countries have economies that several major external shocks have hit in a relatively brief interval — the European sovereign debt crisis, COVID-19, and then the energy price surge that followed Russia's invasion of Ukraine — while they simultaneously strive to reform their formal institutions to meet EU accession requirements (European Commission, 2023). That last part is critical and frequently underappreciated: these countries do not simply react to shocks; they are also in the middle of, partly externally driven, a structural transformation. Standard macroeconomic indicators do not adequately capture the interaction between the two processes. A country can display a reasonable GDP growth and still accumulate fragilities; it can appear stable in theory, but be deeply exposed in reality. That gap has motivated our empirical analysis.

Most formal studies are typically descriptive or policy-oriented rather than composite-index studies, reflecting data limitations and the region's research focus. We fill this gap in the formal literature by constructing a composite indicator of economic resilience based on three dimensions for six Western Balkan countries from 1996 to 2023. To our knowledge, no empirical study has constructed a longitudinal composite indicator to evaluate the evolution of resilience over time and to emphasise the resilience's variability, in particular its stability. In other words, an economy can perform satisfactorily in the overall resilience score while remaining structurally subjected to future deterioration precisely because the foundations of that performance are unstable.

We organise the remainder of this paper as follows. The next section addresses the concept of economic resilience and its measurement. Section 3 presents the data and outlines the statistical methodology. Section 4 illustrates the main findings. Section 5 encompasses the discussion of results, and concludes with some future extensions of the work.

2. LITERATURE REVIEW: CONCEPT AND MEASUREMENT

2.1. What is Economic Resilience?

Economic resilience is a multidimensional concept and methodologically difficult to implement. Etymologically, it derives from the Latin resilīre (‘to spring back’), and the idea first matured in ecology and systems theory before gaining prominence within economics, most notably in regional studies (Holling, 1973; Carpenter et al., 2001; Folke, 2006). In economics, resilience is described as an economy’s capacity to withstand, absorb, adapt to, and recover from adverse shocks while sustaining or realigning core functions (Briguglio et al., 2009; Rose, 2004; Wink, 2012; Martin, 2012; Martin and Sunley, 2015). This view spans multiple layers: (i) engineering resilience (speed of return to pre-shock trend), (ii) ecological/system resilience (ability to absorb disturbances without regime shift), and (iii) adaptive/transformative resilience (capacity to reorganise and evolve in response to structural change) (for instance, Simmie and Martin, 2010; Pendall et al., 2010; Folke, 2006). Empirically, macroeconomic stability (fiscal/monetary buffers), structural features (diversification and openness), institutional quality (governance and the rule of law), and innovation capacity/human capital shape resilience (Hallegatte, 2014; Modica & Reggiani, 2015; Sensier et al., 2016). Small open economies and peripheral regions — including those in the Western Balkans — are more vulnerable to potential exogenous shocks. Accordingly, resilience depends critically on policy credibility, financial depth, and the ability to upgrade in the global value chains (Briguglio et al., 2009; Martin et al., 2016).

2.2. Determinants of economic resilience at the macro level

Some scholars have collected empirical evidence on the factors that elucidate why certain countries avoid recessions when hit by adverse shocks, and why others recover more rapidly and thoroughly. In a seminal paper by Abiad et al. (2009), medium-term output losses (associated with adaptive resilience) were shown to follow financial crises in advanced countries and emerging markets. They indicated that short- and medium-term output losses depend on initial conditions. Eichengreen et al. (2024) identify that stronger recoveries follow deeper recessions. Conversely, more prolonged recessions hurt resilience: protracted downturns erode human capital and yield lasting hysteresis effects, debilitating recovery. Other major determinants with a positive effect on resilience encompass trade and exchange rate flexibility.

However, private credit growth and financial openness undermine economic resilience, with the impact differing amongst emerging vs advanced economies. Giannakis et al. (2024), using a production function framework, analyse the factors that drive regional resilience across a sample of 202 European regions and examine the 2008 global financial crisis. Their main findings suggest that pre-crisis sectoral interconnectedness matters considerably. Specifically, the degree to which agriculture, construction, and manufacturing were structurally integrated within a regional economy shaped how well that region absorbed the negative shock.

Conversely, economies heavily dependent on concentrated export structures are more vulnerable, rendering high export concentration a notable detractor. A recent systematic literature review by Capoani et al. (2025) addresses the primary macroeconomic factors that impact resilience, including human capital (education and skills), SMEs, FDI, labor market dynamics (e.g., unemployment), and workforce stability. Moreover, Hundt and Holtermann (2000) demonstrate that strong national institutions (good governance) improve regional economic resilience for a sample of 249 regions from 1990

to 2014. More recently, Lissona and Ruiz (2025) investigated the economic growth vulnerability of the four largest EU economies (Germany, Spain, France, and Italy) using a multilevel dynamic factor model and concluded that under stress, financial factors are likely to exacerbate the macroeconomic effects of adverse shocks.

2.3. How do we measure economic resilience?

When handling measuring economic resilience, we must address multiple questions. What kind of resilience do we want to measure? (Engineering, ecological, evolutionary, or transformative)? What indicators should be included? Is it regional resilience, organizational, or country-level resilience? Furthermore, we may encompass many other challenging questions (see Sensier et al., 2016; Sutton et al., 2023).

Multiple approaches are available for measuring economic resilience. Common examples cover case studies, composite indices, statistical time-series models, and causal structural models (see Sutton et al., 2023). The formal literature has two strands: one uses unidimensional measures, while the other uses composite indicators, contending that a multidimensional approach is more appropriate for capturing the concept of resilience. Single indicators commonly used as proxies for resilience encompass GDP growth volatility, output loss following a shock, employment levels, fiscal balance/debt ratios, foreign exchange reserves, sectoral shares (e.g., the tourism share), and trade/exports concentration. Certain examples are provided in the literature (Briguglio et al., 2006; Bristow & Healy, 2018; Simmie & Martin, 2010; Martínez et al., 2019). These single indicators might offer several advantages in interpretation. However, they neglect the multidimensional nature of economic resilience.

Another approach involves developing composite indicators that capture the multidimensional nature of the resilience concept. This methodology allows us to incorporate short- and long-term structural changes into a single framework (for instance, Stanickova and Melecký, 2018; Pontarollo and Serpieri, 2018). Other examples of composite indicators are sourced from international organisations, including the OECD and the EU Joint Research Centre.

Additionally, this approach offers several disadvantages, including the choice of indicators, the aggregation method, and poor-quality input data (for an additional discussion, see Nardo et al., 2005a, 2005b). In the latter report, the OECD evaluates the Western Balkans' performance relative to the EU across six clusters: infrastructure, connectivity, skills, business environment, digital transformation, and green transition. For instance, regional R&D investment accounts for only 17% of the EU average, indicating broader deficits in innovation ecosystems and human capital formation. Furthermore, only 34% of adults possess digital skills, much less than the EU's 56%. In the remaining areas, Western Balkans is also behind the EU countries.

Finally, Table 1 presents the main economic resilience indicators developed to date.

Table 1: Economic Resilience Indices

Year	Economic resilience index	Authors	Indicators
2009	Economic resilience index	Briguglio et al. (2009)	Macroeconomic stability, microeconomic market efficiency, social development, and good governance
2015	County economic resilience index	Kahsai et al. (2015)	Industrial diversity, entrepreneurial activity and business dynamics, human and social capital, scale and proximity, and infrastructure
2015	Resilience index	FM Global (2015)	Economic, risk quality, and supply chain
2018	Regional resilience to economic shocks	Bruneckiene et al. (2018)	Insight capacity, regional governance, knowledge and innovation, learning capacity, networking capacity, and regional infrastructure
2023	The economic resilience index	Hafele et al. (2023)	Economic independence, education and skills, financial resilience, governance, production capacity, social progress, and cohesion

Source: Author's elaboration

Our study aligns with the earlier efforts to quantify economic resilience by Briguglio et al. (2009), who underscored broad macroeconomic and governance dimensions, including stability, market efficiency, and social development. Our article grounds the composite indicator of resilience in a theoretically consistent set of dimensions, rather than maximising coverage (by including a plethora of indicators) at the expense of coherence.

3. METHODOLOGY AND DATA

3.1. Methodology

Macroeconomic resilience is the ability of countries to reduce their potential vulnerability to adverse exogenous shocks and to recover quickly (Briguglio et al., 2006; Hallegatte, 2014; Sensier et al., 2016; Martin and Sunley, 2015). Our resilience index (henceforth, CRI) uses macroeconomic data and captures three key dimensions: The first dimension, the absorptive capacity, demonstrates macroeconomic stability- the economy's ability to sustain stable conditions under external pressure (Briguglio et al. 2009). We proxy this dimension through real

GDP growth, which reflects short-run macroeconomic performance and the economy's ability to sustain output during periods of stress, and inflation, which captures price stability. The second dimension, adaptive capacity, denotes the ability to adjust and reorganise in response to changing conditions. Proxy variables, including labour market flexibility, trade openness and economic diversification, measure this dimension. Together, these variables substantiate the rapid reallocation of resources during recession periods. The third dimension, the transformative capacity, signifies the potential structural changes and long-term growth and is proxied by investment in human capital, innovation inputs, and quality of governance.

We follow Rojas-Suarez's (2023) methodological approach to build a simple indicator of macroeconomic resilience for emerging economies. The steps include the following: data normalisation, measurement, and aggregation.

1. Normalisation: All variables are normalised using the min-max approach, and scales are reversed (for instance, unemployment rates and inflation levels) where necessary. Hence, higher values consistently indicate higher macroeconomic resilience. In particular, the transformation scales the data to the range 0 to 1.

$$X_{it}^{*} = \frac{x_{it} - \min(x)}{\max(x) - \min(x)}$$

Where:

- X_{it} = value of indicator i for country and year t
- $\min(x)$ = minimum observed value of indicator i across countries and years
- $\max(x)$ = maximum observed value of indicator i across countries and years
- $X_{i,t}^{*}$ = normalised indicator between 0 and 1

2. Measurement: Each economic resilience dimension (absorptive, adaptive, and transformative) is measured through various indicators. Inflation stability and GDP growth measure the absorptive capacity. The higher GDP value is associated with higher resilience.

However, as the inflation rate increases, resilience decreases. Adaptive capacity is proxied by export performance, unemployment rates, and private and domestic credit. Ultimately, the transformative capacity is captured through education spending, R&D expenditures, and the rule of law as a governance indicator, where higher values across all three indicate greater transformative potential. These components are averaged to form a composite index, with higher values indicating greater economic resilience.

3. Aggregation: The Composite Resilience Index (henceforth, CRI) is then calculated as follows:

$$CRI_{it} = 1/3(Absorptive_{it} + Adaptive_{it} + Transformative_{it})$$

The sub-index i represents country and t the year. The CRI ranges from 0 (vulnerable economy) to 1 (highly resilient economy). The index enables cross-country comparisons of macroeconomic resilience in our sample of six Western Balkan countries. Additionally, this indicator can reflect the short run, the capacity to resist; the short and medium term, the capacity to adapt; and the long-run, the capacity to transform (Martin, 2012; Folke, 2006).

3.2. Data

We used RStudio v. 3.0 for statistical analysis, data extraction, and data visualisation. We developed a simple resilience index for the six Western Balkan countries for the 2000-2023 period. Our sample emerged from the available data. However, some indicators, countries, and years have missing values. Table 2 displays the specific indicators used as proxy variables for the three dimensions of resilience.

Table 2: Variables and data sources

Dimension	Indicator	Definition	Source
Absorptive	Real GDP growth	This variable denotes the annual percentage change in GDP growth (US dollars, constant prices).	World Bank's World Development Indicators (WDI)
Absorptive	Inflation (%)	This dimension measures the annual percentage change in the cost of a basket of goods via Consumer Price Index (CPI).	World Bank's World Development Indicators (WDI)

Adaptive	Exports (% GDP)	It demonstrates exports of goods and services as a percentage of GDP.	World Bank's World Development Indicators (WDI)
Adaptive	Unemployment rates (%)	Unemployment rate (15–74) refers to the percentage of the population in the labour force.	World Bank's World Development Indicators (WDI)
Adaptive	Domestic credit to private sector (%)	It denotes domestic credit to the private sector by banks.	World Bank's World Development Indicators (WDI)
Adaptive	Domestic credit (% GDP)	It depicts credit to households and non-profit institutions, local governments, social security funds, and nonfinancial corporations.	World Bank's World Development Indicators (WDI)
Transformative	Education expenditure (%)	It shows the percentage of GDP dedicated to education spending.	World Bank's World Development Indicators (WDI)
Transformative	R&D expenditure (%)	Research and Development expenditure	World Bank's World Development Indicators (WDI)
Transformative	Rule of Law	The Rule of Law reflects the confidence in the judicial system, contract enforcement, property rights, law enforcement against violent and organized crime, and judicial independence. It is a proxy for the overall quality of the legal system.	World Bank's World Development Indicators (WDI)

Source: Author's elaboration

Table 3 displays summary statistics for the variables used in the empirical analysis. The total number of observations is 144. The sample average for real GDP growth is 3.35. The credit-to-private-sector variable has the highest standard deviation. The mean value of the rule of law is around -0.35, with minimum and maximum being values -1.29 and 0.32, respectively. Education expenditure and R&D have the highest rates of missing values, at 30% and 60%, respectively. To check robustness, we computed the transformative sub-index, excluding education and R&D expenditures entirely. The Spearman rank correlation with the baseline CRI is 0.97, confirming that imputing missing values does not drive our results.

Table 3: Summary Statistics

Variable	Number of observations	Mean	St. Dev.	Min	Max
Real GDP growth (%)	135	3.35	3.42	-15.31	13.04
Inflation (%)	129	4.81	10.78	-2.41	95.01
Exports (% GDP)	136	34.96	11.67	8.24	72.79
Unemployment rate (%)	120	20.63	7.50	8.27	37.32
Education expenditure (% GDP)	43	3.52	0.43	2.74	4.48
R&D (% GDP)	82	0.44	0.30	0.02	1.23
Credit to the Private Sector (% GDP)	107	44.76	13.49	8.05	86.52
Domestic Credit (% GDP)	61	48.94	10.58	33.10	70.19
Rule of Law (RL)	138	-0.35	0.26	-1.28	0.32

Source: Author's elaboration

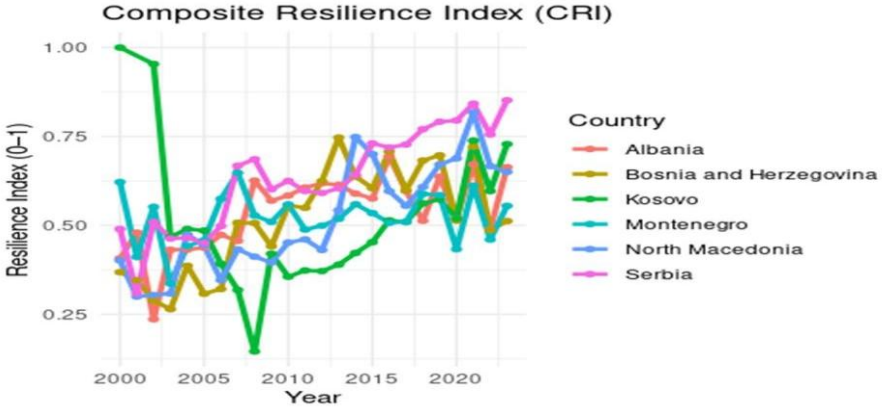
In the next section, we describe the main results of our resilience composite indicator across countries and over time.

4. RESULTS

Figure 1 illustrates trends in the CRI for the six Western Balkan countries over the period 2000-2023. Economic resilience shows a clear upward trend for almost every country between 2000 and 2023. Simply inspecting Figure 1, we can easily identify three groups of countries:

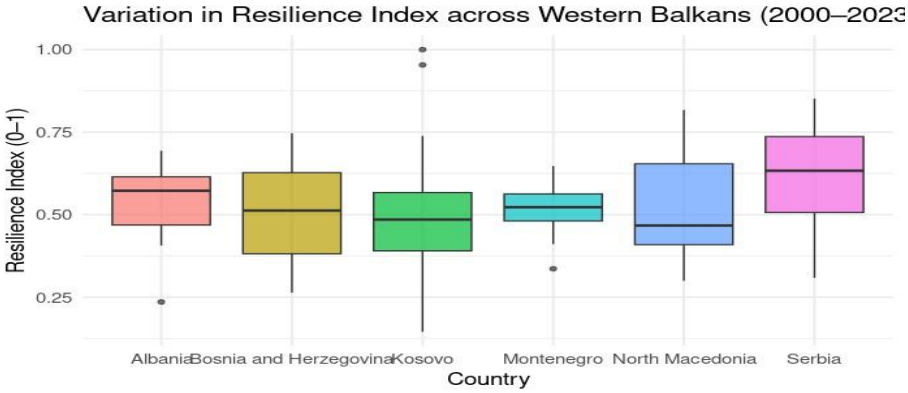
1. Highest Performers, whose scores lie between 0.65 and 0.70 in 2020. Montenegro and Serbia consistently rank amongst the most resilient countries. This finding may be attributed to stronger institutions, a more stable economy or a better adaptive capacity than do their counterparts.
2. Middle Performers, whose scores range from 0.50 to 0.60 in 2020. This group comprises Albania, North Macedonia, and Bosnia and Herzegovina. This cluster shows improvement in economic resilience but still lags behind the highest performers. Furthermore, Bosnia and Herzegovina remained comparatively stagnant between 2010 and 2015, which might be associated with periods of political instability or the aftermath of the 2008 global financial crisis
3. Lowest Performers, whose scores are between 0.25 and 0.40 in 2020. In this group, we find Kosovo, which started substantially lower and, despite improvement, remains behind the other countries in the region. Kosovo has unique challenges as a newer, partially recognised state recovering from the armed conflict. Our descriptive results align with the FM Global Resilience Index (see, for instance, FM, 2025), which ranks countries based on their economic strength, risk quality, and supply chain resilience. Within the Western Balkans, Serbia and Montenegro consistently rank higher -a similar pattern observed in our cluster High group. Albania, North Macedonia, and Bosnia and Herzegovina rank in the mid-tier of the index, which aligns with our intermediate cluster. Kosovo, while absent from the FM rankings due to its partially recognised status, would be assigned to the lowest category, considering the challenges surrounding its infrastructure and institutional development.

Figure 1: Composite Resilience Index (2000–2023)



Source: Author's illustration.

Figure 2: Variation in the Resilience Index across Western Balkan countries. (2000-2023)



Source: Author's illustration.

Figure 2 summarises and depicts the numerical distribution of the CRI across countries. A preliminary analysis indicates that the CRI distribution is uneven across the Western Balkan countries, with median values and variability differing across countries. This finding suggests persistent structural and national economic policy differences in these countries' ability to endure external and domestic disturbances. Moreover, we identify points outside the boxplots for Albania, Kosovo, and Montenegro that may be potential outliers. Countries

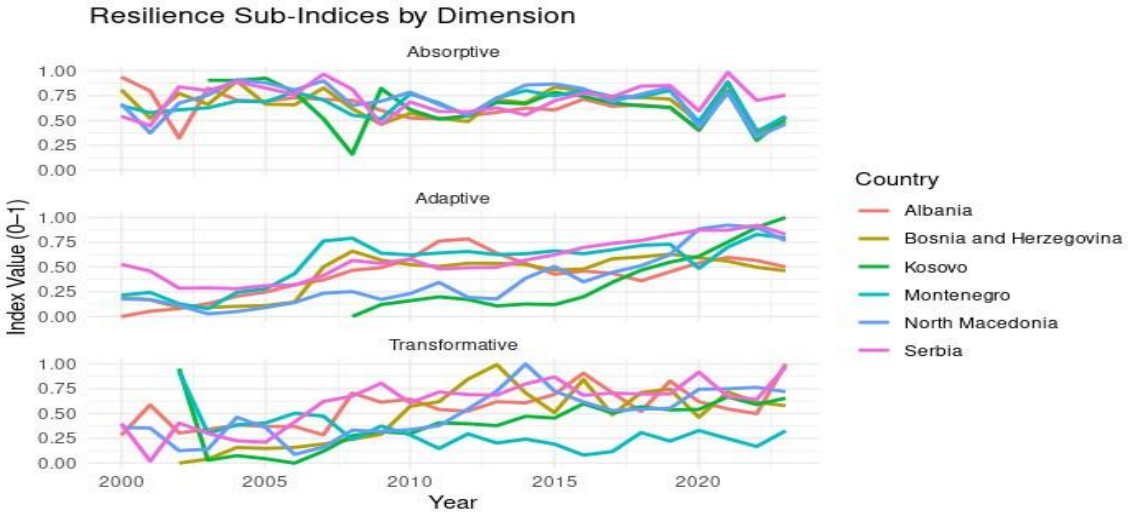
with narrower interquartile ranges exhibit lower variability in resilience scores.

In our sample, Bosnia and Herzegovina has the highest median CRI of 0.50. In contrast, North Macedonia has the lowest median CRI of 0.46. The highest spread is found in North Macedonia, whereas the lowest is observed for Montenegro.

We break down the CRI's total score into three dimensions: absorptive, adaptive, and transformative. Figure 3 illustrates the scores of the resilience sub-Indices (CRI) by dimension for the Western Balkans over the period 2000–2023. Regarding the absorptive dimension, all countries exhibit comparably stable, high absorptive scores ranging from 0.5 to 0.9 over time, with minor fluctuations. This finding implies that the Western Balkans typically have the capacity to absorb external shocks (e.g., through macroeconomic stabilisation and inflation control). Periodic declines in this dimension are associated with major external shocks, notably the 2008– 2009 global financial crisis, and the 2020 COVID-19 shock. This pattern indicates macroeconomic buffering capacity across the region. However, it remains uneven and, in several countries, relatively sparse. The adaptive dimension exhibits a clear upward trend across all countries, particularly after 2010, with values ranging from 0.3 to 0.8. This trend might mirror improvements in trade openness, financial depth, entrepreneurship (as measured by Doing

Business indicators), and labour markets. Certain divergence is evident, for example, with Serbia and North Macedonia leading the way, indicating more substantial progress in building adaptive capacity. Simultaneously, Bosnia and Herzegovina lags relatively behind. The transformative dimension begins at markedly low values (0.1-0.3 in the early 2000s). It then steadily increases in most countries, albeit with some variability. Education, research and development expenditures (R&D), and the quality of governance drive this dimension. Nevertheless, Montenegro is the weakest-performing country in this dimension due to potential institutional bottlenecks. This transformative dimension is the weakest and most unequally distributed across the region, with more volatility than the other resilience dimensions. Nonetheless, it is pivotal for long-term economic resilience and convergence with EU economies.

Figure 3: Composite Resilience Index: Sub-Indices by dimension (2000–2023)



Source: Author's illustration.

5. DISCUSSION AND CONCLUSIONS

Our research suggests that, even though all countries have become more resilient to economic, social, and political shocks, the pace of improvement has varied, resulting in a growing performance gap between the top and bottom countries in the region. The CRI's temporal evolution reveals important asymmetries: Montenegro and Serbia are presented as the regional leaders in building macroeconomic resilience. Concurrently, Kosovo confronts the most notable challenges. In addition, the distribution of macroeconomic resilience across dimensions indicates substantial heterogeneity amongst Western Balkan countries, with the capacity dimension showing the highest scores.

Productivity-enhancing FDI and relatively more stable political environments lead to high CRI Scores, as in Serbia and Montenegro, which enable structural reforms. Conversely, high dependency on consumption-oriented remittances (rather than investment) and political systems that perpetuate instability and block reform lead to low CRI Scores, as observed in the cases of Kosovo and Bosnia and Herzegovina. The variation in the CRI indicates that Serbia consistently attains the highest CRI scores, even though its resilience index values across periods show pronounced volatility. This finding aligns with the economic growth literature, which finds that this intertemporal variability is associated with national economic systems whose adaptive capacity relies

on external conditions (for instance, Ramey and Ramey, 1995). Albania and Montenegro exhibit a relatively stable profile of economic resilience indices. However, they face deficits in transformative capacity for human capital formation, low R&D investment, and weak formal institutions. North Macedonia demonstrates a positive trajectory in the resilience index data. However, North Macedonia's institutional development remains characterised by certain vulnerabilities that may reverse this positive path. The EU Commission lists the main drawbacks as follows: the independence and efficiency of the judicial system and the Rule of Law (see EU 2023). Kosovo displays moderate resilience, but political cycles and governance discontinuity lead to high inter-temporal volatility. Serious concerns about corruption, judicial independence, and property rights enforcement are present, which directly influence the institutional sub-dimension of the resilience index (see, for instance, EU, 2023). Finally, Bosnia and Herzegovina is a special case in the Western Balkans, where political economy constraints do not hinder macroeconomic fundamentals from functioning as the primary obstacle to improvements in economic resilience (see, for instance, Kmezic, 2016).

Future research should examine the nature of the data used to establish the resilience index for six Western Balkan countries. In particular, creating an index across countries and over time using a Principal Component Analysis (PCA) approach with multiway data (countries, years, and indicators) may provide additional methodological insights. The standard approach does not allow for the incorporation of intra-unit correlations. This new methodological approach, developed by Ouyang and Yuan (2025), demonstrates substantially higher efficiency than the traditional approach. Other measures of resilience using similar techniques should be developed at the regional level, aligning with previous studies. We should note that national averages frequently mask regional disparities. Hence, recent approaches have implemented REI at the regional level using PCA (Ilenau and Pana, 2024).

On top of that, other dimensions, such as business operations, should be incorporated into our composite index to reflect transformative resilience fully. In closing, another future extension of this work may involve applying simple imputation methods to address the high prevalence of missing values in variables, including R&D and education expenditures. Moreover, scholars should conduct robustness analysis to test the adequacy of the weighting.

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