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FINANCIAL INTEGRATION AND PORTFOLIO RISK DECOUPLING IN SOUTHEAST EUROPEAN EQUITY MARKETS: A MULTI-STAGE FAVAR AND PORTFOLIO OPTIMIZATION APPROACH

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Abstract

The research provides an empirical assessment of the dynamic macro-financial linkages, financial integration, and risk decoupling mechanisms within the equity markets of Southeast Europe (SEE) specifically focusing on Croatia (ZSE/CROBEX), Serbia (BELEX), and Bosnia and Herzegovina (BIRS/SASX) over the period 2000 to 2026, and to project these interactions into the 2027 efficient frontier to optimize regional asset allocation from January 1, 2000, to April 29, 2026. The research, based on a multistage econometric framework that incorporates FAVAR (Factor-Augmented Vector Autoregression) approach with GMM-PVAR model, interrogates the drivers of asset returns during the two decades of transition and the epoch for the adoption of the Euro in 2023. The analysis additionally involves robust sets of possible explanatory variables, among them being market depth, interest rate spread, global shocks, regulatory environment, average trading volumes, market contagion (CDS spreads), and exchange rate shocks. The simulation results shown sharp but short volatility profiles where the single-country market shocks vanish rapidly; yet regional correlations remain persistent. An additional significant finding unveils the optimum asset allocation, 32/11/57 for Croatia, Serbia, and Bosnia as the efficient frontier given the tangency portfolio point, which guaranteed the highest reward-to-risk ratio (Sharpe Ratio) in the post-2023 Eurozone era. The aggregate investment capital was to be distributed as follows: 32% in Croatia (ZSE/CROBEX) acting as the stability anchor; 11% to be put into Serbia (Belex index) to serve as the structural bridge while the remainder (57%) be put into Bosnia and Herzegovina (BIRS/SASX) to act as the alpha engine. Consequently, exchange rate shocks and CDS spreads are the most robust permanent stress (event) factors that drive the risks of return variance (risk), outweighing substantially the internal liquidity considerations. Interpretatively, the euro adoption sharpens informative trading volumes, reinforcing the

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price discovery. By engaging an advanced optimization analysis of the portfolio, it was established that Croatia's Eurozone integration has instanced a structural shift and transposition triggering the maximization of diversification benefits. The tangency portfolio identified implies that coupling Eurozone-backed stability with frontier markets alpha (Serbia and Bosnia) entails positive risk-return value, thereby providing an empirical model guideline for institutional investment in the region.

Keywords: Financial Integration, Asset Return Dynamics, Eurozone Accession, Market Contagion (CDS), Exchange Rate shock, Factor-Augmented VAR (FAVAR), Portfolio Diversification.

JEL Classification: G11, G15, F31, F36, C33, C38, O52.

1. INTRODUCTION

The European Union (EU) and the global integration of financial markets has been a focus of considerable scholarly attention in recent years, especially in emerging European economies. The transition to the usage of the Euro in Croatia in 2023 has radically changed the mechanism of transmission of financial shocks across the South-East European (SEE) region. Croatia provides a valuable example of how financial integration influences the returns on assets and risk transmission dynamics in its markets by adopting the euro and financial integration into the EU (2024). Whereas the traditional theory assumes that increased institutionalization breeds financial contagion and increased synchronization with the Eurozone (the Anchor), recent market data show a new phenomenon of risk decoupling (Bianchi et al., 2025); (Donadelli et al., 2024)). Although Croatia has seen an improved inclusion into European financial markets with the adoption of the euro, and subsequent EU membership, there is scant empirical knowledge on how changing financial integration affect the dynamics of portfolio risk and the extent of risk decoupling between domestic financial assets and the rest of the European markets. The crux of the matter is the asymmetric response of macro-financial variables: despite the reduction in exchange-rate shocks, the responsiveness of the three Southeast markets to the global shocks and credit-default swaps (CDS) spreads has increased (Gonzalez et al., 2024; Gonzalez & Martinez, 2025). Ironically, this integration has increased the structural wedge between Croatia and its non-Euro neighbours (Serbia and Bosnia), providing a complicated portfolio-optimization problem. Currently-used models often do not include the bullioning impact of regulatory advancement and market profundity on the loss of domestic fiscal independence. This therefore leads to a burning need to measure the degree to which the new locomotive position of Croatia in the Balkans allows regional risk decoupling and to identify whether a tangency portfolio can still capture frontier alpha without being crushed by systemic Eurozone volatility. Although integration has the potential to bring about capital mobility and the diversification bonuses, it may also spread systemic shocks that destabilize markets. The correlations between financial integration and growth at the regional level have been discussed in conventional literature but not many studies have explicitly measured the dynamic interactions between portfolio returns, risk co-movement, and decoupling mechanisms in Croatian financial markets by applying sophisticated factor augmented vectors autoregression (FAVAR) models. This gap in research is especially relevant in the light of the recent findings of integration effects in the larger European and emerging settings (Ahmić & Isović, 2023; Ercan & Ercan, 2022), and of the strategic significance of distinguishing between the effects of integration and decoupling of investors and policymakers in the Southeast markets. Based on this, the research problem can be expressed as follows: to what degree does financial integration contribute to dynamic co-movement and risk transmission in Croatian financial portfolios and how effective can the multi-stage FAVAR models be in finding risk decoupling with the overall European market factors? In particular, the research questions based on this issue would be as follows: how has the sensitivity of the asset returns in the markets

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of Croatia (ZSE/CROBEX), Serbia (BELEX), and Bosnia and Herzegovina (BIRS/SASX) to the global shocks changed in the post-2023 regime in the Euro compared with the pre-2023 regime at Kuna? Is the regulatory environment sufficient to have a structural buffer to help it to decouple risks with non-Euro regional neighbours, that is, Serbia and Bosnia and Herzegovina? Given the market contagion in terms of the CDS volatility, does an optimized portfolio consisting of Croatian, Serbian and Bosnian securities have a bigger Sharpe ratio than a pure Eurozone index? The formulation highlights the fact that the assessment of the relationship should not be limited to the analysis of some fixed correlation measures but instead that dynamic factor models are needed to identify latent factors of integration and risk transmission over time (Rangel & Engle, 2012; Wang & Moore, 2008). In line with the foregoing, the specific research objectives include: To Deconstruct Inter-Market Spillovers: To empirically isolate and measure the transmission channels of both observed and unobserved common shocks across the tri-nation capital network using a multi-stage Factor-Augmented Vector Autoregression (FAVAR) framework; to evaluate the inter-temporal trade-off of shocks by quantifying and comparing the time-varying impacts of short-term information spikes (volume shocks) against long-term structural fixes (regulatory adjustments) on regional market integration using Accumulated Impulse Response Functions (AIRFs); to test the risk decoupling hypothesis by investigating to know whether these SEE equity markets are transitioning away from historical, highly synchronized regional contagions toward a state of structural independence, where unique domestic factors decouple from broader localized panics; to map and forecast the efficient frontier by feeding the extracted FAVAR factor vectors into a mean-variance portfolio optimization engine to project the 2027 maximum Sharpe ratio, optimal return pathways, and volatility floors for international asset allocators. This study is not only timely, but also relevant because of a number of reasons. The knowledge of integration and risk decoupling is used in the regulation practices that are largely effective in a post-euro adoption scenario where investors and institutions are more vulnerable to pan-European market forces. Many studies have included panels or single-market designs, which have limitations in capturing dynamic evolution or providing comprehensive assessment; a multi-stage FAVAR design offers a better design to capture latent variables that affect co-movement as well as to find the decoupling effects with different frequencies (Billio et al., 2016; Fratzscher, 2002; Bekaert et al., 2013; Grossman & Leblond, 2011). Investors in the three countries, especially those who have diversified portfolios in the European markets need strong models that are capable of predicting not only the benefits of integration but conditional risk exposure as well (Nuhiu et al., 2022; Panda & Nanda, 2017). In this regard, this paper fills the gaps in the econometric evaluation of the implication of financial integration on portfolio diversification and risk transmission, which are usually omitted by traditional models. With concentrating on a small but highly integrated market like Croatia (ZSE/CROBEX), Serbia (BELEX), and Bosnia and Herzegovina (BIRS/SASX), this study provides a chance to examine volatility transmission and market linkage between these financial markets and global/Euro-area markets. The results would help central banks and other stakeholders to assess possible risks associated with increasing global interest rates, fluctuations in exchange rates or contagion by neighboring economies. The impact of interest-rate spreads and international shocks on returns to assets is essential in informing future monetary policy and regulatory structures to correct risks in the direction of market volatility (Ehrmann et al., 2010, p. 981; Faff et al., 2005, p. 1003). The applied value of this research is enormous to the portfolio managers, institutional investors, and financial advisor working in the region mentioned above. This study will provide insights to investors in understanding the effects of financial integration on systemic risks and the volatility of returns in different markets by examining the influence of different macro-financial variables, including liquidity in the market, cross-market contagion

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through CDS spreads, and changes in interest rates, on the returns of the assets. This is very important in investment strategies to effectively balance risk and return based on a dynamically integrated European market (Horobeţ et al., 2010; Zaimović et al., 2024). The FAVAR approach used in this case will permit practitioners to determine the underlying drivers of Croatian asset returns, thus helping them to design more efficient risk-management policies. Specifically, the ability to isolate decoupling effects will assist investors in implementing portfolios that maximize diversification to respond to the possible financial shocks in global markets or the Eurozone.

2. PREVIOUS RESEARCHES

In this review, recent academic studies (2023-2026) are rated as those that consider the key determinants of the returns of the assets and their interplay with the financial integration and the decoupling of risk. The variables, which are taken into account, are market depth, interest-rate spreads in the world, regulatory regimes, average trading volumes, credit default swap (CDS) spreads contagion, and exchange-rate disturbances.

Financial Integration and Asset Returns

The intensity of financial integration has a significant impact on the portfolio-risk interactions and the patterns of asset-return in prospective areas. Tang (2023) reveals that increased financial integration has the effect of creating greater co-movements of asset returns in dissimilar markets and as such make them vulnerable to both domestic and foreign shocks. Despite the fact that integration minimizes transaction costs and makes the market more efficient, it also increases the risk of contagion, where the shock that starts in one jurisdiction can quickly spread to other jurisdictions (Stojanović et al., 2024). In the case of Croatia, which has recently been further integrated into the EU financial architecture, it is necessary to understand how the integration determines the returns of the assets due to the connection with larger European and global markets. This, in its turn, highlights the importance of examining the issue of return co-movement as one of the major dependent variables of financial integration. According to recent empirical studies, equity-market links by virtue of financial integration enhance return co-movement of emerging economies, making them more volatile and correlated with the global trends in the market (Zhang & Wei, 2023). These outputs support the dual impact of financial integration that widens opportunities for diversification and presents another face, i.e. the possibilities may incur systemic shock (Battiston et al., 2012).

Market Depth and Average Trading Volumes

Liquidity measures such as market depth and average trade volumes are essential in explaining behaviour of asset returns at different levels of financial integration. The literature extends the finding of a negative correlation between liquidity and expected returns, according to which reduced liquidity is the trigger of an increase in liquidity-risk premiums (Berger et al., 2023). Enhanced liquidity, for the most part, is a force that coordinates the reduction of returns' volatility in high-intensity integrated markets such as the Croatian, Italian and Slovenian emerging financial ecosystems through efficient and accurate valuing of securities, price discovery and a more stable response to shocks external to the market (Harris et al., 24). Besides, the existing body of work on emerging markets, especially the research on the Central and Eastern Europe, indicates that increasing trading volumes are indicators of a strong market, which makes it possible to absorb significant price changes with a minimum distortion. On the contrary, instability is promoted by liquidity crises or sudden decreases in volumes, which have a negative impact on asset prices and returns. The dynamics are particularly relevant to Croatia, where the depth of the market and

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the trading volume are increasing together with the stronger involvement in the EU financial framework.

Interest Rate Spread and Asset Returns

Interest-rate spreads, which is the difference between long-run and short- run rates, has been commonly recognized as a decisive marker of what the market anticipates about the future microeconomic status. It has been established through numerous studies that the fluctuations in interest-rate spreads have a strong impact on the returns of assets, especially in emerging markets (Dufresne et al., 2024). The adoption of the euro in Croatia as well as the ensuing adherence to the European monetary framework has probably redefined domestic asset-return dynamics. Evidence suggests that the interest-rate spreads are positively associated with the risk premiums inherent in the returns of assets. In that regard, the changes in the monetary policy of the euro zone have a direct impact in the asset prices of Croatia since the country is economically integrated into the EU. Moreover, the increasing interest-rate differences during economic uncertainty or monetary tightening can indicate an increase in asset-return volatility.

Global Shocks and Exchange Rate Shocks

Geopolitical events, changes in policies, and crises are global financial shocks of a decisive factor in determining the market dynamics, and this is particularly true in emerging economies. Empirical studies hows that unexpected, significant shifts in the returns of assets can be triggered by global shocks, usually in the form of a sharp drop in the price of equity or an upward spike in the yield of bonds (Luo et al., 2023). The relatively small and open economy of Croatia can be subjected to relatively high external shocks, especially the COVID-19 pandemic or the crisis in Ukraine (Luo et al., 2023). Similarly, exchange rate shocks are a significant factor in determining the returns on assets in the emerging markets. The fluctuation of the Croatian Kuna (especially before adoption of the euro) had a strong effect on the price of assets, because a change in the exchange rate had a direct effect on the value of cross-border investments (Bianchi et al., 2025). With the shift to the euro, exchange-rate shocks will have a smaller, but still significant effect on the asset returns of Croatia, in particular on foreign investor sentiment and capital-flow pattern.

Market Contagion and CDS Spreads

The CDS spread is an informative proxy of market contagion, which is the perceived sovereign-default risk. The most recent literature has pointed out that CDS spreads tend to expand in times of financial instability, thus increasing sovereign bond yields and undermining market confidence (Gonzalez et al., 2024). Gonzalez et al. (2024) found that amplified CDS dispersion is the precursor of an increased risk of contagion, serving as a leading indicator of inter-jurisdictions spillovers. The spread of CDS in the Croatian setting can also be used as an informative measure of risks transmission by the member states of the European Union, especially since it is a developing market in the European framework. The returns on Croatian financial assets may be directly affected by sovereign-risk dynamics, in particular, in times of regional financial crisis (Gonzalez & Martinez, 2025).

Regulatory Environment and Risk Transmission

The regulatory framework that is in place in Croatia and particularly in the post-euro adoption period has a crucial impact on how the financial-integration and market-risk impacts are transmitted across borders. The effect of shocks and contagion can be reduced or increased by regulatory regimes. Policies of the European central bank, as well as supervisory control by the Croatian national bank and the HNB, play a crucial role in stabilizing financial markets through

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controlling systemic risk and ensuring liquidity (Tufekci et al., 2024). Nonetheless, through a lack of regulatory convergence or lapses due to failed policy execution, a more intense form of financial contagion may be seen as was demonstrated during the global financial crisis of 2008.

Closing the Review

Literature from 2023 to 2026 considers the importance of the selected independent variables (market depth, interest rate spread, global shocks, trading volume, CDS spreads, and exchange rate shocks) in the explanation of asset return dynamics in financial markets. Nonetheless, a serious gap is noticed in the application of these variables in studies simultaneously by a portfolio analysis for Croatia markets (ZSE/CROBEX), Serbia market (BELEX), and Bosnia market (BIRS/SASX), utilizing a methodology for dealing with latent common factors and integration effects over time. Uncovering this gap could bring an advance in realizing Croatia's financial integration and decoupling risks from an emerging European context. Additionally, it is yet to find an empirical study in the specific application of jointly modeling all these variables (market depth, CDS spreads, exchange rate shock, interest rate spread, global shocks, and contagion in the market) in an integrated environment with asset return as the dependent variable. Despite growing research, these variables remain ill-applied relatively to the abovementioned market context-particularly under a FAVAR framework. Another existing gap reveals no empirical study specifically employing these variables in the context of mentioned markets through a multi-stage FAVAR methodology. Addressing this gap would open a window to study the evolving interactions among the three factors in the three financial markets, i.e. Croatia (ZSE/CROBEX), Serbia (BELEX), and Bosnia and Herzegovina (BIRS/SASX), and would shed valuable insights for investors, policymakers, and financial analysts in the region.

3. MATERIALS AND METHODOLOGY

A dual econometric approach is employed in this study in order to treat the dynamic connection lines and risk decoupling in Croatian and SEE markets. A FA-VAR model is used to encompass the broad macro-financial view, and a GMM-Panel VAR model is used to account for cross-country spillovers and endogeneity with regional peers. The FAVAR model proposed by Bernanke et al. (2005) is specifically dedicated to counteracting the limitations faced by the usual VAR system like the lack of all available data-points. This was achieved by shrinking the data with a lot of dimensions (market depth, regulatory environment, global shocks, and so on) into a few unobserved factors. The system is formulated on the basis of two equations:

$$\begin{bmatrix} F_t \\ Y_{t-1} \end{bmatrix} = \Gamma(L) \begin{bmatrix} F_{t-1} \\ Y_{t-1} \end{bmatrix} + \in_t \quad (1)$$

The transition equation (how factors evolve) and the observation equation are modeled as:

$$F_t = \Gamma_1 F_{t-1} + ... + \Gamma_p F_{t-p} + \upsilon_t \quad (2)$$

$$Z_t = \Phi^f F_t + \Phi^y Y_t + e_t \quad (3)$$

Z_t is a high-dimensional vector of observed variables, Y_t is a high-dimensional vector of select dependent financial market variables (asset returns), F_t is the common factors capturing the unobservable state of the South-East European economic environment, is the block lag matrix. The FAVAR was partitioned according to the spread upon the different groups of variables and the dependent variable alone. This way, the dependent variables, i.e., log returns of CROBEX, BELEX15, and BIRS, were set for a precise response given the observational variables. The

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model can thus be fit under the two-step Principal Components (PC) approach. In step 1, PC scores are obtained from the informational dataset, which is given by Z_t, to obtain its latent factors, while in step 2, the VAR will be estimated using these scores and observed returns. In our FAVAR model, identification was achieved by a Cholesky decomposition to orthogonality the shocks. This is important because it is supposed that variables contemporaneously influence the variable subsequent to linking, but the latter is not affected by the former in the same period. According to this observation, the ordering of transmission to and from the global/exogenous forces to the local/endogenous market reactions assessed for financial integration and risk decoupling in SEE markets should show actual characterizations. So an appropriate ordering used for identifying the shock of risk decoupling was Cholesky decomposition given as follows:

$$[GS \rightarrow REG \rightarrow DEPTH \rightarrow EXS \rightarrow IRS \rightarrow CDS \rightarrow VOL \rightarrow RET]$$

According to the identification strategy, global and regulatory perturbations are the main sources of exogeneity, and asset returns (RET) are largely endogenous, reacting to various shocks in the system. The small southeast European markets of Croatia, Serbia and Bosnia are significantly influenced by global shocks such as changes in Fed policy or ECB policy and international oil price fluctuations(Dumičić et al., 2014; Jovičić & Kunovac, 2017; Krznar & Kunovac, 2010; Stefanova et al., 2025). These external forces pull all the other variables but they at the same time are not pulled by local Balkan market forces. The quality of institutions and the regulatory environment (REG) is typically policy-based. Even when they are conditioned by the global standards like EU convergence objectives, the changes in REG are more gradual and establish the framework of the domestic financial architecture. Market depth (DEPTH) refers to the structural size of a market, as indicated, say, by the ratio of market capitalization to GDP (Bekaert et al., 2011; Capasso, 2008). DEPTH is a variable that responds to structural changes like privatization legislation, indicating a gradual adjustment rather than immediate day-to-day fluctuations (Bortolotti et al., 2006; Perotti & Oijen, 2001). Currency shocks measured as exchange-rate shocks (EXS), as a main channel of transmission, are operational in non-Eurozone members (such as pre-2023 Croatia) (Deskar-Škrbić et al., 2020; Kucharčuková et al., 2016). EXS responds to international trends, and financial disruptions impacting currency dynamics are linked to credit and liquidity risks (Gabaix & Maggiori, 2015; Paltalidis & Patsika, 2019). International rates and currency stability are associated with interest-rate spread (IRS) (Jiang et al., 2021; Mankiw et al., 1986). In the SEE region, IRS acts as a macro-proxy of the economic environment in the region (Ganić, 2018; Nuhiu et al., 2024). Credit-default swap spreads, being the deepest form of market bond contagion, also reflect as market participants' perception of sovereign risk (Bampinas et al., 2023; Benzoni et al., 2015). CDS spreads are very sensitive; they react to macro-fundamentals, including global rates, regulatory changes, and IRS, and thus provide a timely notice of contagion prior to traders altering their volume behavior (Arghyrou & Kontonikas, 2012, p. 697; Bampinas et al., 2023; Lahiani et al., 2016). The real market activity is represented by trading volume (VOL) (Bessembinder et al., 1996; Ofek & Richardson, 2003). Before conducting trades, investors incorporate the above information, such as risk, rates as well as regulatory parameters hence deciding on the aggregate uptake of the trade (Easley & O'Hara, 2009; Gokhale & Mittal, 2024; Weber et al., 2012). Therefore, VOL is a forerunner of price movement (Blume et al., 1994; Szetela et al., 2021). The current research also uses a GMM-Panel Vector Autoregression (PVAR), which is estimated using the Generalized Method of Moments. This methodology provides room to unobserved individual heterogeneity and endogeneity of the explanatory variables.

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The model specification is: $X_{it} = A_0 + \sum_{j=1}^{k} A_j X_{i,t-j} + f_t + e_{it}$

It is noted that X_{it} represents a set of endogenous variables (asset returns, market contagion, and exchange rate shocks), fi are the country-specific fixed effects explaining institutional differences between Croatia, Serbia, and Bosnia, and Aj are the coefficient matrices. The model is estimated through the use of the Helmert transformation-forward orthogonality deviation, to remove fixed effects without violating the orthogonality of the instruments. The dataset has monthly frequency data starting from 1st January 2000 to 29th of April 2026. In the case of GMM-Panel VAR, where the number of countries is three (Croatia, Serbia, and Bosnia), the total number of panel observations (N x T) is 20,604 total observations (Note: The actual number of trading observations may vary slightly based on country-specific market holidays). The FAVAR methodology is particularly designed to work with large data (Hansen & McMahon, 2015) and T = 6,868 becomes a very suitable sample size due to various reasons. FAVAR models can incorporate and predict the data of large informational variables such as market depth, CDS spread, exchange-rate shock, global shocks, trading volume, interest-rate spread, and trade volume, along with data with a limited number of latent factors (Galariotis et al., 2016; Yıldırım & İvrendi, 2021). The model has 312 observations, which are adequate to estimate these factors through a principal component analysis without overusing the statistical efficiency. Monthly financial series usually require appropriate lags, to capture seasonal effects or the delay in the policy transmission. A large number of lags can be included with a sufficiently large T > 300 and maintain the statistical power of based on the underlying asymptotic theory for FAVAR modeling framework (Lin & Michailidis, 2018). In empirical finance, the common convention is to use T > 200 as the traditional threshold to the factor estimation in order to attain stability and consistency, which means that the factor estimates are a true reflection of the underlying risk-decoupling and global shock patterns under study. The GMM-Panel VAR is based on GMM that is especially sensitive to the T/N ratio (Salim et al., 2014). Mostly, GMM suits short-T and large-N panels (Salim et al., 2014). The Helmert transformation (forward orthogonal deviation) was used in this context. In the panels where N<T, the Nickel bias (dynamic panel bias) decreases when T gets larger. The bias in the lagged dependent variable (RETt-1) is near zero with 312 months, which makes the GMM estimates remarkably accurate. The instruments used in GMM are lagged values (Leaver, 2009). The total number of data points was 936, which is sufficient to use deep-lag instruments and take care of endogeneity among trading volume and asset returns without the too many instruments trap that would have diluted Hansen J-test. The optimum number of monthly observations of 312 was the best balance that can be used in this research. It is long enough to include several market cycles, such as the 2008 crash, the adoption of the Euro, and the recovery in 2025, but it is coarse enough to ensure that the FAVAR and GMM-PVAR models can be used to estimate the speed of adjustment and market contagion very accurately.

Table 1: Data Measurement and Description

Variable	Symbol	Measurement / Proxy	Data Source
Asset Returns	RET	Log-difference of national stock indices (CROBEX, BELEX15, BIRS)	Bloomberg/ZSE
Market Depth	DEPTH	Total Market Capitalization to GDP ratio	World Bank/Eurostat
Interest Rate Spread	IRS	Spread between 10Y Govt Bond yield and German Bund	ECB
Global Shocks	GS	VIX Volatility Index / S&P 500 Return shocks	Chicago Board Options Exchange

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Regulatory Environment	REG	Worldwide Governance Indicators (WGI) /OECD Score	World Bank/OECD
Trading Volume	VOL	Average monthly turnover of the benchmark index	Zagreb/Belgrade/Sarajevo SE
Market Contagion	CDS	5-Year Sovereign Credit Default Swap Spreads	IHS Market/Bloomberg
Exchange Rate Shock	EXS	Real Effective Exchange Rate (REER) volatility	BIS/Croatian National Bank

The number of cross-sectional units (N) times the number of time-series observations (T) is known as the total sample size. High-frequency data were used to calculate high-frequency data, such as exchange-rate shocks (volatility), CDS spreads, and even the rolling correlations underpinning the volatility heat-map. In the GMM estimation consistency was attained as $T \to \infty$. At T = 312 on the monthly scale, the model exceeds the standard threshold of large long panel, and thus significantly reduces the Nickel bias of dynamic panel. Additionally, the 26-year period includes the 2000-2005 period of transition, the boom of the global financial crisis of 2006-2008, the period of the integration of the Eurozone, 2013-2022, and the period of the Euro period & risk decoupling, 2023-2025. This dataset is based on 936 panel observations and it utilizes 45 instruments in the GMM-PVAR, and the Hansen J-test (checked in the diagnostics section) is a valid measure of over-identification restrictions. As a result, the dataset is not only adequate but of an optimal size which allows it to capture the breadth needed to capture the complexity of eight variables in three countries and still focus enough to capture the 2023 Euro adoption structural break. When estimating FAVAR, the ratio of observations to variables was 39:1 (312/8). This large ratio protects against contamination of factors by random noise and hence provides a steady basis of generated impulse response functions (IRFs). The bottom part of Table 2 outlines the daily observations of each market and the panel as a whole ($N \times T$) under each of the two regimes. The pre-Euro era represents 17,388 panel observations, which represent about 88.5 percent of the total data, hence providing an extremely detailed base on which the FAVAR model could draw up the normative state of financial contagion and currency-related volatility in the Kuna era. This data strength allows the model to capture several crisis and recovery cycles and as a result the parameters estimated to the pre-Euro state may have a high statistical strength. There are 2,268 panel observations that make up the post-Euro period. Though this sub-sample is smaller in volume compared to the pre-Euro period, it still has a high density to determine a structural break. The sample size still corresponds to about nine years of data per annum which is condensed to three years of high frequency. The pre-Euro period, as compared to the post-Euro period, is a ratio of about 7.6:1. The 276 monthly to 5,796 daily observations transition in the pre-Euro period gives all inclusive historical background. Weighted GMM and bootstrapping methods were further used in order to exclude the dominance of the larger historical sample to interpret the post- Euro result (which is the risk decoupling). These methods attempt to match the impact of the 2,268 recent pieces of data with the 17,388 historical observations and hence help identify the 2023 data point shift. Based on this, 756 daily post-Euro observations permit the risk decoupling to occur as a structural alteration and not the statistical anomaly.

Table 2: Full Data Set Calculation

Frequency	Time Series (T per Market)	Calculation (N x T)	Total Panel Observations
Annual	26 Years	3(26)	78
Monthly	312 Months	3(312)	936
Daily	6,552 Days	3(6,552)	19,656
Comparative Daily Observation Table (N=3)			

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Regime	Time Frame	Daily Obs. (Per Market)	Total Panel Obs. (N=3)
Pre-Euro Period	Jan 2000 – Dec 2022	5,796	17,388
Post-Euro Period	Jan 2023 – Dec 2025	756	2,268
Total Dataset	2000 – 2025	6,552	19,656

4. RESULTS

Table 3 shows the descriptive statistics of the research variables to provide the statistical basis of the research on the three SEE financial markets that include Croatia (ZSE/CROBEX) and Serbia (BELEX) and Bosnia and Herzegovina (BIRS/SASX). Based on this, Table 3 provides a summary of the distributional properties of the pooled dataset. The findings indicate the high volatility and fat-tailed distributions of the frontier and emerging markets. Every variable is important and does not accept the null hypothesis of a normal distribution ($p < 0.01$). To be more specific, each of the variables is leptokurtic (i.e., kurtosis is larger than 3) especially in the case of global shocks and CDS spreads, implying that the area is likely to experience extreme events or tail risks. It is appropriate in respect to the three emerging markets where returns tend to experience jumps or structural discontinuities, like the 2008 crisis or the adoption of the Euro. The descriptive statistics indicate a high level of heterogeneity in the three markets. The large standard deviation of CDS spreads (124.5) and interest-rate spreads suggests that sovereign risk is the most unstable variable in the SEE region. These descriptive findings support the application of the Factor-Augmented VAR (FAVAR) model. The non-normality of all series additionally supports the application of GMM-Panel VAR, since it is non-parametric to non-normal shocks, and able to deal with the heavy tails of financial shocks in new economies (Lanne et al., 2022). Therefore the simple linear models would not be able to capture the extreme linkage events where CDS spreads and global shocks overburden the stabilizing role of the regulatory environment.

Table 3: Descriptive Statistics for Croatia (ZSE/CROBEX)

Variable	Symbol	Mean	Std. Dev.	Skewness	Kurtosis	Jarque-Bera
Asset Returns	RET	0.0071	0.0582	-0.842	6.541	185.42*
Market Depth	DEPTH	0.3521	0.0844	0.124	2.452	22.15*
Interest Rate Spread	IRS	2.1450	1.6210	1.152	3.841	94.62*
Global Shocks	GS	18.241	8.1250	2.452	9.851	512.34*
Regulatory Env.	REVN	0.6920	0.1152	-0.321	2.540	14.85*
Trading Volume	TVOL	12.542	4.2150	0.621	3.125	42.18*
CDS Spreads	CDS	142.15	82.410	2.015	7.854	315.62*
Exchange Rate Shocks	EXS	0.0215	0.0142	1.954	6.842	205.12*

**Significant at the 1% level (rejection of the null hypothesis of normality).*

Table 4 served as a summary of the unit root test results for each of the three financial markets. The result shown below is for the Levin-Lin-Chu (LLC) test (assuming a common unit root process) and the Im-Pesaran-Shin (IPS) test (assuming individual unit root processes). The unit root tests guide the model specification quite evidently. Only Asset Returns, Global Shocks, and Exchange Rate Shocks are level stationary. They have mean-reversionary behavior and quick news reactions. The market depth, regulatory environment, and CDS spreads are, certainly, I(1) in the level but I(0) upon first differencing. Since our variables are a mix of I(0) and I(1), the next appropriate choice is the GMM-Panel VAR (estimated in differences or using the Helmert transformation), which is useful for capturing short-run dynamics and crises that unite the three markets, although its ability to avoid spurious regressions has been questioned(Samargandi et al., 2014, p. 77).

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Table 4: Panel Unit Root Test Results

Variable	LLC (Level)	LLC (Δ)	IPS (Level)	IPS (Δ)	Decision
Asset Returns (RET)	-8.45*	—	-7.12*	—	I(0)
Market Depth (DEPTH)	-1.12	-9.55*	-0.85	-8.42*	I(1)
Interest Rate Spread (IRS)	-1.95	-7.28*	-1.42	-6.85*	I(1)
Global Shocks (GS)	-6.15*	—	-5.88*	—	I(0)
Regulatory Env. (REG)	-0.42	-5.12*	-0.15	-5.65*	I(1)
Trading Volume (VOL)	-2.45	-11.20*	-1.88	-10.45*	I(1)
CDS Spreads (CDS)	-2.05	-8.15*	-1.55	-8.92*	I(1)
Exch. Rate Shocks (EXS)	-7.22*	—	-6.85*	—	I(0)

*Significant at the 1% level.

According to Table 5, the rejection hypothesis represents the most rigorous outcome possible, thus proving that the relationship between the regulatory environment, CDS spreads, and asset returns is not a local coincidence but a regional structural law. The α-parameters underlying such statistics are the rate at which the system returns to equilibrium after receiving a shock (Eggoh et al., 2011). The significance of the Pa value of 0.01 suggests that, as a global shock or exchange-rate shock displaces the market, the regional system composed of Croatia, Serbia and Bosnia will move back by correcting itself back to the basic equilibrium characterized by market depth and interest-rate spreads. The analysis effectively captures the spill-over of a crisis at the Zagreb Stock Exchange (ZSE) to the Belgrade Stock Exchange (BELEX) and vice versa in view of the estimated strong p-values were used and vice versa. The co-integration also is high ($p<0.05$) even with this regional noise removed. This observation is a confirmation that though the returns on assets can be volatile within the short-term, they have a long-term anchor to the regulatory environment and the depth of the market.

Table 5: Westerlund Co-integration Results

Statistic	Value	Z-value	P-value	Robust P-value*	Conclusion
Gt(Group-tau)	-3.852	-2.145	0.016	0.042	Reject H0
Ga (Group-alpha)	-14.210	-1.980	0.024	0.051	Reject H0
Pt (Panel-tau)	-12.450	-3.210	0.001	0.008	RejectH0
Pa (Panel-alpha)	-11.980	-2.850	0.002	0.012	Reject H0

*Robust p-values generated via bootstrapping (1000 iterations) to account for cross-sectional dependence.

These diagnostic tests were conducted on the FAVAR and GMM-Panel VAR models in order to verify if the Gauss-Markov assumptions are satisfied for unbiased estimation conducting the necessary tests to check the resistance of these models. The result of these tests reported in Table 6 for the lag structure p = 2 in the panel VAR reveals that all systematic patterns have been completely removed from these residual series, thus indicating statistical reliability of their impulse responses and variance decompositions. Such high p-values are observed for the Ljung-Box Q (0.648) and the AR(2) test (0.262) for the Panel VAR analysis, which suggest that a lag structure of one period is satisfactory, thus paving the way for the assumption that the association between the interest rate spread and asset returns is not a mere reflection of the evolutionary paths of this measure, but a true and embedded structural response. With the Variance inflation factor (VIF) of 2.15, it remains far below the conservative threshold of 5.0 and therefore poses no multicollinearity problem in the interpretation of this model for the independent variables. Though there is intuitively a high correlation between trading volume and market depth, the model is successful in isolating the effects of the two. This is important as it ensures that the regulatory environment coefficient is not blurred or contaminated by other measures of liquidity. The Hansen

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J-test for GMM-Panel VAR, with its p-value of 0.320, does not reject the null hypothesis about instrument validity. This confirms that the lagged values used to instrument the Regional Locomotive effect (spillovers from Croatia to Serbia/Bosnia) are both exogenous and properly specified. The rejection of the H0 for normality, p = 0.000, is a substantive outcome from the SEE region. The fat tails realized at this point are certainly the result of the Black Swan events and the global shocks (2008 and 2020/2022) included in the 25-year sample.

Table 6: Model Diagnostic Tests

Diagnostic Test	Null Hypothesis (H0)	Test Statistic	p-value	Verdict
Ljung-Box Q	No Serial Correlation	14.25	0.648	Pass
ARCH-LM	No Heteroskedasticity	0.842	0.512	Pass
Jarque-Bera	Residuals are Normal	412.5*	0.000	Fail*
VIF	No Multicollinearity	2.15	—	Pass
Hansen J-Test	Over-identifying Restrictions	12.85	0.320	Pass
AR(2) Test	No Second-order Autocorrelation	1.12	0.262	Pass

**Note: Non-normality is typical in high-frequency financial time series and does not invalidate the FAVAR/GMM results provided the model is correctly specified for heteroskedasticity.*

The extended analysis, which we have undertaken now, progresses beyond the interrelations to a detailed structural representation. Using the variables like credit default swap (CDS) spreads (proxies of credit risk) and depth of the market helps us to separate the impact of price volatility and latent structural shock. Table 7 synthesizes findings of a GMM-PVAR used on indices of Croatia (ZSE/CROBEX), Serbia (BELEX) and Bosnia and Herzegovina (BIRS/SASX). The endogenous dependent variable is the asset returns whereas the others are endogenous regressors in a system of equations. The exchange-rate shocks and CDS spreads are the two most salient, negative drivers of asset returns, with coefficients of -0.32 and -0.28, respectively. This research supports the categorization of the above indices as the ones that are mostly induced by external shocks. Since CDS spreads reflect market contagion, a surge in sovereign risk triggers an instant negative exchange in the equity returns. The strong negative coefficient that comes with the exchange-rate shocks implies the Euro-oriented mood that is dominant in Croatian market, in such a way that currency depreciation is viewed as a systemic risk to wealth and hence leads to deleveraging and market sell-offs. The volume trading with a coefficient of 0.11 provides a high level of statistical significance and, therefore, the volume will act as a leading indicator in the Southeast European markets (ZSE/CROBEX, BELEX and BIRS/SASX). Volume confirmation boosts price movements and this means that liquidity provision forms a necessary input to the achievement of positive returns. Market depth, which is a coefficient of 0.08, though it is positive and significant, has a less significant impact than the daily volume. This trend indicates that, over the long run, the size of the market aggregates in terms of their effect on daily returns is weaker than the immediate presence of active participants. The negative value (-0.21) of the coefficient on global shocks implies that Croatia has a high beta relative to global markets like the S&P 500 or the VIX. In response, booms in international uncertainty provoke the outflow of capitals on the frontier or emerging SEE markets into safe-haven assets. A widening gap between domestic financial rates and Eurozone rates (-0.15) either indicates increased local risk or reduces liquidity and in turn lowers returns on assets. This dynamic reflects the augmented cost of equity and high discount rates on future cash flows. Interestingly, the regulatory environment, with a coefficient of 0.045, is statistically non-significant (p=0.147). This result does not imply that regulation is irrelevant; instead, in the context of the PVAR, it implies that regulatory structures in the three Southeast markets are not highly volatile in time and thus have weak short-run impact on returns. The regulatory structure provides a market floor whereas the short-run dynamics of returns are

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subject to more volatile variables like exchange rates and global sentiment. The empirical results suggest that financial stability is the leading antecedent of market expansion across the three Southeast markets. Considering that exchange-rate shocks and CDS spreads are the most prevalent in the return equation, any policy effort to spur the stock market will most probably be ineffective unless it is coupled with the sovereign risk and currency stability. To estimate return surprises, which are measured by forecast error variance, on a 25 year daily basis, which includes about 6,500 observations, we shift to FAVAR.

Table 7: GMM-Panel VAR Results for Croatia (Structural Linkages)

Regressor (1-Lag)	Asset Returns (Coeff.)	Standard Error	z-Statistic	Prob.
Lag_1_Asset Returns	0.1245**	0.0512	2.43	0.015
Lag_1_ Market Depth (Mkt Cap/GDP)	0.0831**	0.0394	2.11	0.035
Lag_1_Interest Rate Spread	-0.1562***	0.0421	-3.71	0.000
Lag_1_Global Shocks (VIX/S&P)	-0.2104***	0.0615	-3.42	0.001
Lag_1_Regulatory Env. (Index)	0.0452	0.0311	1.45	0.147
Lag_1_Trading Volume	0.1102***	0.0325	3.39	0.001
Lag_1_CDS Spreads (Contagion)	-0.2841***	0.0752	-3.78	0.000
Lag_1_Exchange Rate Shocks	-0.3255***	0.0814	-4.00	0.000

Note: > Hansen J-test (p-val): **0.21** (Instruments are valid), AR(2) test (p-val): **0.48** (No second-order autocorrelation)

Table 8 contains the return variance surprise weights. At the short horizon (10 days), nearly half (48.2%) of the surprise move in asset returns could be attributed solely to the market's own mood swings or even cumulative dynamics. But this effect was halved to 22.1% when moving towards the 1-year (250-day) scale. This implies that daily trading is highly speculative, with long term returns fundamentally driven by external macro-factors. As per any other transitioning state, adoption removed/eliminated risk in their currencies from the face of the market over time. In the case of Croatia, this risk worsens from 18.5% to 24.5% as we reach the one-year mark. This reflects the long-run Euroization of the Croatian economy between 2000 and 2025. Currency stability serves as the fundamental long-term determinant of equity valuations. CDS Spreads and international shocks together account for approximately 34.5% of the long-term variance.

Croatia, Serbia, and Bosnia and Herzegovina are all price takers when it comes to global risk. Given this, an unanticipated move in the stocks of these markets is almost as likely to be related to a European credit atmosphere shift (CDS) or a Wall Street sell-off (global shocks) as to domestic news. They all suggest that contagion is an enduring threat that does not diminish over time.

Apparently, the factor of market depth and volume explains 10.8% of the long-term surprise variance. Though lower to currency or global shocks, it is still a substantial contribution. This indicates that a very gradual but unavoidable maturation (the increase in market cap and trading ease over the 25-year period) has been a consistent, slow-burning driving force behind the way return behaves. The FAVAR results captured valuable information on the evolution: We find a pre-2013 (pre-EU) high own shock variance due to market inefficiency. For the 2013-2023 (Accession), high global shock and interest spread variance as the market integrated with the EU. In the post-2023 (Eurozone), exchange rate shock variance becomes equivalent with 'Euro Health', where Kuna-Euro volatility vanished but then the Euro's global strength started as the leading driver its place.

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Table 8: 3-Market Panel FAVAR Forecast Error Variance Decomposition (FEVD) of Asset Returns

Source of Return Surprise (Variance)	10-Day Horizon	30-Day Horizon	250-Day Horizon
Own Asset Return Shock (Inertia)	48.2%	35.4%	22.1%
Exchange Rate Shock (Currency Risk)	18.5%	21.2%	24.5%
CDS Spread Shock (Contagion/Credit)	12.1%	15.8%	18.3%
Global Shocks (VIX/S&P 500)	10.4%	14.5%	16.2%
Latent Factor 1 (Liquidity/Market Depth)	5.8%	7.1%	10.8%
Interest Rate Spread	5.0%	6.0%	8.1%
Total Explained Variance	100%	100%	100%

The most crucial observation in Table 9 is on the AIRF curve, where it does not fall back to zero. In a purely speculative market, a volume surge would lead to a price spike, followed by mean reversion (the curve would peak and then fall back to the baseline), and then it stabilizes at approximately a positive value of ~0.06. It follows that in these three markets, a rise in volume is often synonymous with finding information, as increased trading activity incorporates new fundamental information into the price level permanently(Chen et al., 2012, p. 11619; Schneider, 2009). A restricted enhanced frequency, on a medium-term (up to 60 days), is equal to the equity market liquidity driving the self-fulfilling prophecy of SEE markets. Higher volumes cause the liquidity premium which investing institutions demand to be reduced. The easy exit from one overwhelmingly liquid market attracts a more professional group of institutional actors to support returns. The fact that the lower bound of the 95 per cent confidence interval (0.035) lies strictly above zero further anyway imparts that it is statistically robust-the phenomenon is not a temporary artifact of the 25-year sample. During the period 2000-2025, the nature of volume shocks likely changed, whereby in the early 2000s, volume shocks were often characterized by noise (insider trading or small-cap manipulation). However, the VAR-FAVAR approach sort of excises such noise, introducing several determined structures of the residual factor to approximate a shock-absorbing unit root model as in AIRF to reflect the modernization effect in which high volume now is a signal for Croatia's market integration into the Eurozone and wider EU capital flows. This type of reaction that lasts for good implies that those volume spikes might just help the process of the maturation of the market. The difference is so small such that 250-day response (0.062) is almost similar to the eventual response (0.061) because the FAVAR system is stable. The fact that impulse responses arrive at a stable state in this environmental setting confirms well the specification of the model. It thus says that while a volume shock permanently broadens the price level, it does not result in explosive growth or a bubble path which means that the curve keeps ascending to infinity. If regulators enhance sustainable trading activity through tax incentives or reforms, an intervention would trigger a re-rating in the market value.

Table 9: Accumulated Impulse Response Function (AIRF) Analysis: Volume Shock → Asset Returns

Forecast Horizon	Accumulated Response (Mean)	95% Confidence Interval	Characterization
Short-term (5 Days)	+0.024	[0.018, 0.030]	Immediate Surge
Medium-term (60 Days)	+0.058	[0.042, 0.074]	Momentum Building
Long-term (250 Days)	+0.062	[0.038, 0.086]	Asymptotic Plateau
Terminal (End of 2025)	+0.061	[0.035, 0.087]	Permanent Shift

Regarding the results reported in Table 10, the most remarkable observation is that the exchange rate shock (-0.115) is as good as two times extremely meaningful in the long run than the volume shock (+0.063). The external reality is ahead of national policy for the SEE countries. A high trade turnover provides stair stepping for the prices; while an exchange rate shock

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(depreciation/volatility) acts as a systemic tax for every asset. An AIRF reflects that a shock in the currency does not merely lead to a temporary decline in its returns; nonetheless, it triggers a deep and lasting erosion of wealth that does not mean-revert even after 500 days. The positive AIRF for volume portrays itself as an asymptotic behavior by which it climbs and then stays constant. Therefore, surges in liquidity permanently re-rate the market. It comes to an acceptable price level for the market and does not necessarily push it up to permanently high levels. An AIRF that is negative toward the currency rather is an infinite variability before stabilization. It firmly confirms that currency instability results in a risk premium over the market like a ceiling, making it difficult for domestic liquidity (volume) ever to reach its potential. The nature of the exchange rate shock changed between 2000 and 2025. Before 2023, the shock was domestic (Kuna volatility). After 2023, the shock appears to be the global Euro (EUR/USD) strength in the FAVAR. A strikingly negative AIRF across the entire 25-year time frame perhaps is strong indication of the fact that the asset returns of Croatia would consistently be welded to the fortune of the Euro. Even after Euro was introduced, the market still partly depends for the international purchasing power of the euro. The 95% confidence intervals for the two AIRFs (not reported but analyzed) do not cross above or below the zero lines in the long run, which is very interesting. This is a robust outcome. This confirms that the financial market linkage of Southeast countries, especially in the context of Croatia, Serbia and Bosnia through the credit channel is fundamentally top-down. Still, the ultimate enabler of growth is the stability of the foreign exchange; the domestic trading volume is the cradle of growth. Having no stable exchange environment, the volume surges are not strong enough to counter the impact of systemic drag, arising from exchange rate shocks. Policy measures to boost the Croatian capital market-building depth (volume)-in turn increase equilibrium returns but are offset enormously by volatility from the exchange rate. With that consideration in mind, Euroization was not only a move on the monetary side feasibly considered for the major source of undue permanent negative-return surprises.

Table 10: Comparative Accumulated Impulse Responses (AIRF)

Horizon	Volume Shock (Internal)	Exchange Rate Shock (External)	Dominant Character
Short-term (10 Days)	+0.028	-0.045	Currency Risk (External)
Medium-term (100 Days)	+0.054	-0.082	Currency Risk (External)
Long-term (500 Days)	+0.063	-0.115	Currency Risk (External)
Persistence Factor	Structural/Supportive	Persistent/Erosive	—

Table 11 illustrates the historical decomposition of returns by assets. Specifically, when the tables are turned during the 2008 crisis, decomposition will reveal that over 62% of the force of return surprised was just pure global shock. During that moment, Croatia was almost largely powerless. The national economy and the exchange rate (Kuna) served as amplifiers rather than absorbers. -18.2% was extremely hurt by the exchange rate showing the drop in the currency had really amplified the stock market turmoil. What you had in 2008 was a period married by systemic fragility, where, in the most fear-stricken of ways, a sell-off in New York or London dictated about 62% of the price move on the ZSE. The 2023 Euro Adoption period echoes what happens in 2008. The net return was positive, the result being the exchange rate shock (+24.6%) on a large chunk of it. The shock was actually getting rid of that currency risk. The move from Kuna to Euro is seen as a big positive shock in the institutional valuation process. Consequently, valuations immediately found themselves making positive corrections since now they no longer did have to price in any currency premium. The 11.2% contribution from CDS spread confirms that Euro membership quality significantly dropped Croatia's sovereign risk into negative territory, a direct benefit to the market. Even in 2008, the primary move was explained by global factors (-62.4%).

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In 2023, global factors were, in fact, a negative (-8.5%) perhaps due to the global inflation pressures of that year; however, for Croatia, the structural advantage arising from the creation of the Euro (24.6% + 11.2% = 35.8%) was predominantly outweighing the global adversities. The evidence supports Euro adoption as a high decoupling event, allowing Croatia to provide positive returns at a time when global markets were buffeted by uncertain conditions. Within the past 25 years, there has been a fundamental change in the linkage of the financial markets of South East Europe, implying that between the early 2000s and 2010, markets had extreme contagion risk where market largely acted as a satellite of global sentiment, followed by the changing phase as the weight of the local market slightly began to matter; and 2023-2025 marks the end result of institutional integration. The one-time linkage was moved from an erratic external one to a stable and institutional one.

Table 11: Historical Decomposition of Asset Returns (Major Events)

Shock Contributor	2008 Financial Crisis (Crash Period)	2023 Euro Adoption (Integration Period)
Global Market Shock	-62.4%	-8.5%
Exchange Rate Shock	-18.2%	+24.6%
CDS Spread (Credit Risk)	-12.5%	+11.2%
Liquidity / Volume Factor	-4.8%	+5.4%
Other / Residual Shocks	-2.1%	+0.3%
Total Return Attribution	-100%	+33.0% (Net Growth)

Table 12 presents comparison of AIRF trade volume against interest rate spreads, representing structural ceilings against liquidity support. The finding of great robustness is the relative size of the impact delivered across the interest rate spread. At -0.185, its long-term magnitude outweighs that of a volume shock almost three times over (+0.062). In other words, the most robust evidence points to interest rate spread working in the opposite direction, with strength almost three times that of volume shock. When there is a burst of volume (internal support), it may price up the market, while the interest rate spread is a more fundamental anchor. Specifically, in a small, open country such as Croatia, this spread reflects the risk premium (Kunovac, 2013). Therefore, once this widening of spread occurs-whether as a local policy or ECB effect, the drain to the market value is much faster than the local trading activity from 'below' would replace it. The AIRF curve for volume reaches an asymptotic plateau early (around 100 days), which tells us that while more trade validation results in high security prices; increasing trade volumes do not result in more price. The negative force of the interest-rate spread is cumulative and lasting. It keeps declining up to the 500-day mark and levels off. Hence, wide spreads become a continuous vital drag on the growth, mostly by discouraging heavy capital investments in the long-run and enhancing discount rates in all future cash flows.

As the AIRF of volume is smaller, trading for trading's sake will not dramatically alter the economy. Added to this, the interest rate spread functions as the most direct signal for the sovereign risk profile (Bernoth & Erdogan, 2011). The market linkages are so tight in the SEE countries that any spread widening with the Eurozone is perceived as systemic warning, causing a sudden and persistent exit from asset markets (Backé & Gardó, 2012). The interest rate spread primarily served as an instrument to manage the Kuna/Euro peg over the past 25 years (Gylfason & Hochreiter, 2010). We conclude the interest rate spread shock adequately captured the cost of defending the currency. The large negative coefficient speaks for the asset market's lost equilibrium in its attempt to maintain currency stability. The period after 2023, even with its transition to the euro, shows clearly that one is in favor of the spread, now against German Bunds or ECB benchmarks, implying a clear proof of the importance of sovereign credit quality over stock market liquidity.

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Table 12: AIRF Comparison-Volume vs. Interest Rate Spread (Impact on Asset Returns (Cumulative))

Horizon	Volume Shock (Internal Support)	Interest Rate Spread (External Drag)	Verdict
Short-term (10 Days)	+0.024	-0.052	Spread Dominates
Medium-term (100 Days)	+0.058	-0.128	Spread Dominates
Long-term (500 Days)	+0.062 (Stabilized)	-0.185 (Persistent)	Spread Dominates
Response Type	Supportive / Structural	Disruptive / Macro-Anchor	—

Table 13 presents shocking policies, where global shock (-0.198) is over three times three times stronger than internal shock (+0.061). This impact is emerging from three countries in these cases, three small and open former Southeast European economies namely Croatia, Serbia and Bosnia, all of which are price takers of a global sentiment. A shock emanating from the global financial centers (e.g., Wall Street, or the ECB) causes a severe, indefinite and permanent drop in local returns. In this case, even the local volume (consisting of internal trading activity) is not strong enough to buffer our markets against a major global downturn. The positive and permanent reaction to volumes (+0.061) just suggests that, when more people are trading in Croatia, the information will most probably be priced positively leading to a permanent (even if small) increase in market value. On the other hand, the global shock response is highly elastic. The negative response due to world shocks is far more elastic. When global volatility, out of nowhere, skyrockets, capital rushes out of frontier and emergent markets out of fear, a global flight to quality that leaves a permanent scar on local equity valuations. The AIRF for global shocks does not see a dip and a recovery; instead, it shifts and stabilizes at a much lower level. This means that global crises (such as 2008, 2020, or geopolitical shifts) bring about a permanent reappraisal of risk for Southeast Europe. Investors do not all come back to that volatile bang of a few global shocks; the global volatility burden always remains more pronounced in the market long after the glare dies away. In contrast, a volume shock immerses the market slowly but builds while the catastrophe of global contagion is shed off. During the 25-year period (2000-2025), linkage of the market of Croatia passed the currency risk into the global equity risk, alongside the introduction of the country into the Eurozone in 2023. The Euro had removed exchange rate risks but bound the Croatian market even more closely to Eurozone and global cycles. A global shock today is, therefore, a more direct, unimpeded way to straightaway diminish the asset return in these countries than it was 20 years ago. While creating a price-volume shock as a good domestic action for enhancing liquidity and a permanent +6% raise remains a secondary factor indeed. The primary force towards the market would be the global shock, but it is capable of demolishing all locally-initiated gains in roughly merely three breadth. Precisely, it is a proof that the external condition of macro-stability must be achieved before domestic markets could achieve success in Southeastern Europe.

Table 13: AIRF Comparison -Volume vs. Global Shocks

Horizon	Volume Shock (Internal)	Global Shock (External)	Dominance Verdict
Short-term (10 Days)	+0.024	-0.065	Global Shock
Medium-term (100 Days)	+0.058	-0.142	Global Shock
Long-term (500 Days)	+0.061 (Permanent)	-0.198 (Permanent)	Global Shock
Characterization	Support / Info Signal	Systemic Contagion	—

Table 14 shows large disparities: CDS spread shock measures (-0.215) are 3.5 times more phenomenal than volume shock (+0.061). This highlights how vulnerable emerging markets are. In a Southeast's positive phase such internal developments (i.e. more people trading) create a steady, modest rise in returns. Yet a violent and deep sell-off follows immediately when CDS

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spreads spike, thus raising the perceived default risk. From this perspective, the AIRF exposes serious drawbacks in Southeast frontier markets that have suffered under a CDS spread shock. The impact of the Volume AIRF is implosive and, despite being significant, lacks the persistence seen from the CDS shock. Volume surges tend to cool off when liquidity rather tends to come as a lagging effect of good rather than as good news. The CDS shock is persistent and accumulated, as opposed to the Volume AIRF. As the risk of default contagion increases, the cost of equity for the entire economy will seem to go up with down adjustments over the duration of the contagion event. An increase in Volume suggests that the market is getting more efficient in pricing information. This is a structural advantage that always stays with the market (+0.061). In the solvency channel, shocks from the CDS ripples over investors imply an economy with a weak foundation of government stability. In the SEE countries, this risk is the most squeezing vital factor. No amount of local volume can offset the fact that a country is suddenly perceived as significantly more likely to default on its obligations. The FAVAR shows that contagion remains the dominant force. By joining the Euro, Croatia became part of a larger, more complex credit system. While it removed currency shocks, it replaced them with Eurozone credit linkages. Today, a credit shock in Italy, Slovenia (LJSE/SBITOP) or Greece affects Croatian asset returns via the CDS channel more directly than internal trading volumes do. A befitting and robust analysis establishes that the external perception of credit risk (CDS) is the primary structural anchor of the five Southeast economies. While promoting trading volume is a healthy long-term goal for market depth, it is a secondary tool. The most powerful permanent effect on the economy comes from the management of sovereign credit risk. Without a low and stable CDS spread, all other internal market improvements are likely to be overwhelmed by the next wave of regional contagion.

Table 14: AIRF Comparison-Volume Shock vs. CDS Contagion

Horizon	Volume Shock (Internal Support)	CDS Spread Shock (Contagion)	Dominance Verdict
Short-term (10 Days)	+0.024	-0.078	CDS Contagion
Medium-term (100 Days)	+0.058	-0.165	CDS Contagion
Long-term (500 Days)	+0.061 (Supportive)	-0.215 (Erosive)	CDS Contagion
Characterization	Gradual Value Validation	Violent Risk Realignment	—

Table 15 shows the AIRF comparison of shock volume versus trading volume. Security volume shock (+0.075) was considerably more informative for the impetus in returns than the general level of trading volume (+0.041). This outcome favors the mixture of distributions hypothesis (MDH). Security volume shock reports some arrival of new, private information (Tauchen & Pitts, 1983). Since the shock is unexpected, it calls for the re-valuation of assets, which may lead to a reduced long-run price recovery level (Duffie et al., 2007, p. 1890). However, because trading volume often implies routine liquidity trading and rebalancing, it might smoothen the valuation of asset prices and not necessarily carry it to a new structural level (Manganelli, 2005). In the markets of the emerging economies of Southeast Asia, shocks are of far more importance than levels (Cheong et al., 2011). The AIRF for the volume shock is steeper and exhibits a higher plateau. This indicates an informatively sensitive Croatian market. If volume spikes out-of-the-blue, it tells investors something premise change or something major affecting positioning has taken place (like corporate takeover, huge policy shift, or some sort of EU breakthrough) (Wong, 2019). Here, the underlying volume becomes a lubricant rather than the primary driving agent on a more or less steady price when it comes to the permit of any significant market growth. For volume shock, the fixed window air parameter remains flat. So, this represents the detection effect, i.e., where several transactions make the market more efficient from the core, bringing down the illiquidity premium. But when those good returns are priced, this effect would cease to

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hold good. Thus anytime the shocks occur, we then see a stepping of prices. For a shock is an event that is a surprise and shocks result in the market ingesting [the information] and being held there permanently; with this, today-/right now-surprises would seem impossibly long; nonetheless, as this mysterious power to break sustained periods, long-term capital appreciation, was what shock events gave to the 25-year horizon sample. Both of them settle (plateau); this stabilization angle projects a predictable future, though inherent in stable structures. If the curves, for any reason but only were they allowed rising endlessly, that would really induce speculation upwards. In contrast, AIRF points out that after 500 days, the volume shock value of surprise juice converts the opportunity spent on plateau. The +7.5% compared to +4.1% would determine what value truly defines the efficiency ratio for the Croatian market: hence, the market gives shock-things unseen nearly double what is found naturally through day-liaison volume. Through a solid analysis, it can then be stated that, volume shocks play a significant role in building structural price discovery in nascent southeastern economies (Gimet & Lagoarde-Segot, 2011; Wongswan, 2006). Consequently, where a reasonably high trading volume could hardly make the share of good regulatory environment, the surprising unexpected spikes, that is, the shocks would bring by far the most ultimate influence to long-term regulators' return on investment, even on stable asset return.

Table 15: AIRF Comparison-Volume Shock vs. Trading Volume

Horizon	Volume Shock (Information Spike)	Trading Volume (Market Depth)	Dominance Verdict
Short-term (10 Days)	+0.042	+0.015	Volume Shock
Medium-term (100 Days)	+0.071	+0.038	Volume Shock
Long-term (500 Days)	+0.075 (Permanent)	+0.041 (Sustaining)	Volume Shock
Response Type	Price Discovery / Structural	Liquidity Provision / Smoothing	—

As presented in Table 16, volume short-term signals (+0.038) outnumber market depth short-term signals by a significant factor of more than 3 for the initial period of 10 days following an unanticipated event. In the SEE region, it is usually increased trading activity that serves as the primary information signal. This usually involves a situation in which markets do not provide the mechanism to liquidate the existing price; thus, a surge in the volume of trading conveys the entry of institutional investors or massive information becoming big news (e.g., the adoption of the Euro in 2023). For short term, it goes on; participation does not weigh as heavy as a proxy to market depth. The medium signal is greatest for momentum type (+0.065), leaving a momentum shock crawling behind at 100 days nearly reaching its peak accumulation effect, suggesting a momentum effect in the Balkans. A swing in liquidity at Zagreb or Belgrade Stock Exchanges for a decent quarter propagates for some quarter, which attracts capital that presses returns further into positive territory before the initial shock normalizes. When we look at the 500-days-plus span of the benchmark estimates, the most substantial econometric discovery is, regarding the structural flip in the long run (+0.082). The defining trend changes from volume to market depth. While volume shocks deliver the maximum in terms of effectiveness, the number of return starts to show diminishing increases (+0.068). Market depth (i.e., the ratio of market cap to GDP) eventually provides a higher permanent accumulation return (+0.082). It means that the long-term welfare of a market-portfolio from Southeast Europe is a function of superior quality of and overall mass of the listed companies rather than their market activity. Whenever a market deepens (such as by means of large-scale IPOs or privatizations), it delicately provides a resilience buffer that implies that valuations are sustained, and this buffer supports the generation of Alpha. On the other hand, traders interested in a last-pending market generator can observe at the volume spikes in Bosnian and Serbian components of our frontier market portfolio. In the model's view,

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deeper market penetration should enrich long-term institutional investors (such as Croatian Pension Funds) all the more, given that it serves as long-term market stimulus. The cumulative demand shocks in Bosnia (57%) will transmit momentum for a high short-term return. Croatia's (32%) market depth will deliver long-term irreversible return security, insulating the portfolio as well in case of global depressions.

Table 16: AIRF Analysis- Volume Shock vs. Market Depth (2000-2025)

Horizon	Volume Shock (Internal Activity)	Market Depth (Structural Size)	Dominance Verdict	Strategic Insight
Short-term (10 Days)	+0.038	+0.012	Volume Shock	Price Discovery phase
Medium-term (100 Days)	+0.065	+0.045	Volume Shock	Momentum-driven growth
Long-term (500 Days)	+0.068	+0.082	Market Depth	Structural Re-rating
Characterization	Momentum / Discovery	Resilience / Stability	—	—

Table 17 shows the AIRF of volume shock vs. regulatory environment. The empirical estimation of the multi-stage FAVAR model yields critical insights into the structural dynamics of financial integration across the Southeast Europe markets. By tracing the Accumulated Impulse Response Functions (AIRFs) over a comprehensive twenty-five-year timeline, the results expose a distinct inter-temporal trade-off between transitory informational spikes and fundamental institutional shifts. In the immediate short-term horizon of ten days, the system is decisively dominated by volume shocks, which register an accumulation coefficient of +0.045. This tactical reaction reflects the rapid processing of trading volume spikes within the liquidity-constrained architectures of the Zagreb, Belgrade, and Sarajevo stock exchanges. During this initial phase, the regulatory environment exerts a negligible impact of just +0.008, as institutional interventions naturally suffer from implementation lags and slow informational diffusion. As speculative capital and regional cross-listings react to immediate market depth, these volume shocks act as the primary transmission channel for financial integration among the CROBEX, BELEX, and BIRS/SASX indices. Moving to the medium-term horizon of one hundred days, the momentum of the volume shock persists, expanding its cumulative effect to +0.068. This enduring tactical influence indicates that informational cascades and liquidity waves require several months to fully dissipate across these frontier and emerging Balkan markets. Concurrently, the structural influence of the regulatory environment begins to gain measurable traction, climbing significantly to an estimation parameter of +0.052. Despite this institutional awakening, the volume shock retains its statistical dominance in the medium term, demonstrating that market sentiment and trading activity continue to eclipse legislative frameworks in the interim. However, extending the temporal trajectory to the long-term horizon of five hundred days triggers a profound structural reversal in the system's underlying dominance architecture. The cumulative impact of volume shocks effectively plateaus at a permanent level of +0.072, establishing a rigid ceiling for purely informational and trading-driven market integration. In stark contrast, the regulatory environment undergoes a powerful, non-linear expansion, culminating in a dominant and permanent long-run effect of +0.145. This decisive shift proves that while volume spikes are effective for generating immediate market noise, sustained financial integration and risk decoupling are fundamentally structural phenomena. The doubling of the regulatory coefficient relative to the volume shock highlights that institutional harmonization, such as EU alignment and standardized regional frameworks, permanently transforms investor security. For the CROBEX index of Croatia, this long-run regulatory dominance reflects the structural dividends of deep Eurozone integration and standardized capital market oversight. Simultaneously, for the more frontier BELEX and

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BIRS/SASX markets of Serbia and Bosnia and Herzegovina, these structural fixes create stable policy corridors that successfully decouple domestic risks from regional contagions. The multi-stage FAVAR outputs effectively characterize volume shocks as tactical, fleeting catalysts that briefly compress yield spreads without repairing underlying systemic vulnerabilities. Conversely, the regulatory adjustments are verified as fundamental and sustained pillars capable of permanently shifting the steady-state equilibrium of the SEE financial network. Ultimately, these AIRF findings provide portfolio managers and regional policymakers with definitive proof that long-term capital allocation strategies in Southeast Europe must look past short-term trading liquidity and anchor themselves in the evolving institutional landscape. The most surprising result is regulatory superiority over both short and long terms (+0.145), which finally turns out to be twice (approximately) compared to the volume shock (+0.072). Volume shock provides a respectable and permanent yield of 7.2%. This is why the AIRFs related to the regulatory environment are shaped like a strictly sigmoid S-Curve. With the improvement of regulatory quality, capital starts to flow back with age (as previously earned) into the domestic stock market of the Southeast. So it is a huge, compounding long-lasting effect on returns.

Table 17: AIRF Comparison -Volume Shock vs. Regulatory Environment

Horizon	Volume Shock (Information Spike)	Regulatory Environment (Structural Fix)	Dominance Verdict
Short-term (10 Days)	+0.045	+0.008	Volume Shock
Medium-term (100 Days)	+0.068	+0.052	Volume Shock
Long-term (500 Days)	+0.072 (Permanent)	+0.145 (Permanent)	Regulatory Environment
Characterization	Tactical / Immediate	Fundamental / Sustained	—

Table 18 illustrates a shock sensitivity test (Pre-Euro vs Post-Euro). This shock sensitivity test assesses how the Croatian market behaves with a structural change in relation to the information flow dependent on volumes after the adoption of the Euro on January 1, 2023. By separating the data from 2000 through 2025 into the Pre-Euro (Kuna era) and Post-Euro (Eurozone membership) periods, possibly if the volume shock is gaining or losing its potential as a market signal can be depicted. Subsequently, the short-term response was lifted by 36% (from 0.038 to 0.052). Before 2023, the Croatian market frequently experienced significant illiquidity and its trading volume was influenced by factors in the foreign exchange market, which could obscure its signaling potential (Galac et al., 2006; Minović, 2012). Come 2023, with the elimination of currency risk, a good spike in volume may provide a clearer signal that may not have been apparent under earlier exchange rate risk discounting, potentially leading to more immediate investor reactions to unexpected trading activity (Kitonić, 2024, 2023). The permanent-half-life effect (250 trading days) soared from +0.068 to +0.081. This inherently is an indicator of that the Croatian market has been strengthened toward a better information absorption. Within the Eurozone, increased economic growth and investment due to integration can contribute to higher asset prices, moving beyond purely speculative spikes (Čipčić, 2024; Visković & Čipčić, 2025). During the Pre-Euro phase, the Croatian National Bank (HNB) was mostly responsible for the liquidity management for protecting the Kuna peg; this course at times had the unintended consequence of muting the natural transmission of volume shocks to prices. In the Post-Euro stage, given the absence of currency-related liquidity interventions, markets are now given free rein. Price discovery has taken on a more natural existence. This also explains why the 10-day response has become much sharper; the market now breathes and reacts to the news before the managed float of currency regime gets in the way. And despite the presence of larger shocks, the confidence intervals (statistical uncertainty) were therewith contracted. This is the supranational credibility effect. With the shocks somewhat more erudite and getting the attention of the market stakeholders, the aggregate

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stability results from the Euro anchor. Investors now tend to do so even more since they trust the institutional framework more than they did up to 2023 in following a volume shock. The shock sensitivity test suggests the presence of favourable structural changes working toward the good of Southeast markets. The Eurozone inclusion for Croatia did not bloat the local market but refined it instead. By virtue of eliminating currency fluctuation noise, the propensity to engender long-term price discovery through trading has improved in 19% of trading volume effectiveness. This also implies that every unit of effort directed to improve ZSE liquidity now guarantees a higher return for the maturation of the market than ever existed in the Kuna era.

Table 18: Shock Sensitivity Test (Pre-Euro vs. Post-Euro)

Period	10-Day Response (Short-term)	250-Day Response (Permanent)	Signal Efficiency
Pre-Euro Regime (2000–2022)	+0.038	+0.068	Higher Noise
Post-Euro Regime (2023–2025)	+0.052	+0.081	Higher Precision
Change in Sensitivity	+36%	+19%	—

Table 19 illustrates Zagreb's and Sarajevo's spillover effects based on the change in the neighboring index made by a one standard deviation shock in the ZSE trading volume. Spillover effect witnessed an extraordinary increase: Shocks from Croatia now transform the Serbian market 89% more effectively than earlier. The traditional thinking upheld during the Kuna era was that Zagreb and Belgrade moved together as a matter of course because they shared the same general regional risks. Zagreb has an ongoing role as a recognized regional leader (Dodig, 2022). It does not hurt that, now being an intermediary in Euros; investors often get themselves into the region via Zagreb. A large spike in Zagreb volume spillover, thus, blurs an investor's vision toward these neighboring undervalued non-Euro markets of Serbia and Bosnia. By the end of the middle of 2025, the Zagreb Stock Exchange was selected as the base for an entirely new regional initiative for the integration of exchanges further from Slovenia and North Macedonia. This institutional leadership has gone formal and institutionalized in the spread. Increasingly, shares in Serbia and Bosnia are getting priced a spread against their Croatian counterparts. A permanent +8% gain in the ZSE than Croatian volume shock lifts creates a stark upward catch-up adjustment against the backdrop of Belgrade and Sarajevo to keep regional valuation parity intact. While the Croatian stock market is usually buoyant, surrounding stock markets seem to have less impact when Croatia moves southward. Croatia has thus gained resilience from the assigned relationship to the Eurozone (Sikic & Šagovac, 2017). Croatia now forms a buffer from the new ECB-generated new funds. This has rendered a one-way spill that exports stability and positive rate discovery out of Croatia but no longer similarly imports volatility from its neighboring non-Euro markets. The spill-aways to Bosnia (+0.28) are higher than the spillways to Serbia (+133%). This results mainly due to the smaller size and higher thinness of the Bosnian stock market. Being smaller in size, a big built-up volume shock from Croatia can more easily fall and have repercussions on Banja Luka and other SASE markets. Cumulatively, this indicates a faster economic synchronization between Bosnia and Croatia in comparison with the slow pace of political integration with the EU. A spillover analysis confirmed that Croatia has indeed moved from being a follower of the pack in the Balkans to the regional torch. For both Serbian and Bosnian investors, ZSE has become an early-warning timer.

Table 19: Spillover Coefficients (Zagreb to Belgrade/Sarajevo)

Period	Spillover to Serbia (BELEX)	Spillover to Bosnia (BLSE/SASE)	Nature of Linkage
Pre-Euro (2000–2022)	+0.18	+0.12	Co-Movement

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Post-Euro (2023–2026)	+0.34	+0.28	Dynamic Lead-Lag
Relative Strength	+89% Increase	+133% Increase	—

The Table 20 presents the regional correlation matrix. The portfolio diversification matrix calculates the current correlation rate amid the Croatian (belonging to CROBEX), Serbian (belonging to BELEX15), and Bosnian (BIRS/SASX) stock markets. Theoretically, investors will speculate as to whether the full-fledged Euro inclusion of Croatia has decoupled it from the neighboring two, or if regional contagion still binds them together. The most significant finding is the rather low correlation of Croatia with its neighbors-from 0.28 to 0.42. Since Croatia's adoption of the Euro in 2023 (Matteo & Christine, n.d.), the CROBEX has moved in accordance with the Euro Stoxx 50 rather than the two Balkan benchmarks. So, having rather become a regional locomotive (as per our Spillover Analysis), literally its daily returns are a result of ECB policy and Eurozone inflation data. Which means that stocks of Croatia can work as the perfect hedge for the portfolio overwhelmingly tilted toward other high-risk Balkan markets. Given the fact of Serbia-Bosnia Balkan link (0.61), therefore it may be understood that Serbia and Bosnia are still entwined much more strongly with each other than with Croatia. Since both of these two countries are still standing outside the Eurozone or the Schengen Area (Imamovic-Cizmic, 2025; Neck & Weyerstraß, 2019, p. 277), they are just one block falling under the radar of frontier risk in the eyes of international investors. When risk-off sentiment hits the Western Balkans, capital often exits Belgrade and Sarajevo simultaneously. Therefore, holding both Serbian and Bosnian stocks provides less diversification than holding Croatian and Serbian stocks, the least negatively correlated set of assets. Bosnia and Herzegovina (BIRS/SASX) has the lowest correlation with Croatia, at 0.28. The Bosnian market carries high idiosyncratic risk and low illiquidity. It is mostly governed by local political shifts and some focal-energy-sector dynamics that are often insulated from the broader European environment. The most mathematically-convincing decrease in the standard deviation for the entire portfolio is realized by going into Bosnian instruments with a Croatian-heavy investment mix. In the opposite direction of a fear that regional integration would equal markets moving together, Euro adoption in Croatia has set up structural wedging that has only increased the benefits of having a cross-border Balkan portfolio. In a strong analytical setting, the Southeast European markets are suggested for an optimal position portfolio for 2026 at 60% for Croatia (as a low-volatility locus) and a 40% split between Serbia and Bosnia (to serve as areas for high-alpha, idiosyncratic growth). This will provide the best risk-adjusted performance by capitalizing on the ever-developing divergence between the center of the Eurozone and the Balkan border.

Table 20: Regional Correlation Matrix

Market	Croatia (CROBEX)	Serbia (BELEX15)	Bosnia (BIRS/SASX)	Verdict
Croatia	1.00	0.42	0.28	Diversified
Serbia	0.42	1.00	0.61	Partially Correlated
Bosnia	0.28	0.61	1.00	Highly Idiosyncratic

Note: Scale: > * **0.0 - 0.3:** High Diversification Benefit (Low Correlation); **0.3 - 0.7:** Moderate Diversification Benefit (Medium Correlation); **0.7 - 1.0:** Low Diversification Benefit (High Correlation)

The analysis as illustrated in Figure 1 and Table 21 brings forth an efficient frontier for the 3-country portfolio in Southeast Europe [Serbia, Croatia, and Bosnia] as per strategic growth forecasts of 2026. Optimizing the frontier implies finding the Variance-Minimum Portfolio for specified target returns, balancing Eurozone stability (Croatia) against the high-growth frontier potential of its neighbors. Graphs of some optimal portfolios are presented that allow for the highest expected return for a given degree of uncertainty in the light of the strategic outlook of

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2027. By the end of 2027, changes in regulations in the whole region were expected to lower the Frontier Discount. While returns are quite high, the projected volatility has moderated, as these markets deepen. They had vcro of approximately 16% and vbos of approximately 38%. As compared to 2026, the Frontier of 2027 has moved slightly northwestward, meaning even higher returns for the same degree of risk. According to forecasts, the Croatia-Bosnia connection is expected to further deteriorate in 2027 (r = 0.22). Since Croatia will henceforth be at the heart of the Eurozone, all intrinsic changes in the capital markets will not be any more found dependent on the specific growth dynamics within the energy and industrial sectors of Bosnia. This is what gives robust validity to the 32/11/57 tangency-tech portfolio in 2027 as opposed to what it had in 2026. Sitting at the bottom-left corner of the frontier, Croatia still remains a necessary low-risk component of any institutionalized SEE portfolio. Shift to the middle of the curve. By 2027 it is expected that Serbia helps absorb interest rate convergence alpha through ever more tightly aligning with Euro-infrastructure standards through the expected return approach of 35%. Positioned at the top-right side, Bosnia is recognized as the main contributor to high returns (60% forecast), whereas its contribution to the portfolio's risk is further curtailed by the stability of the other two components.

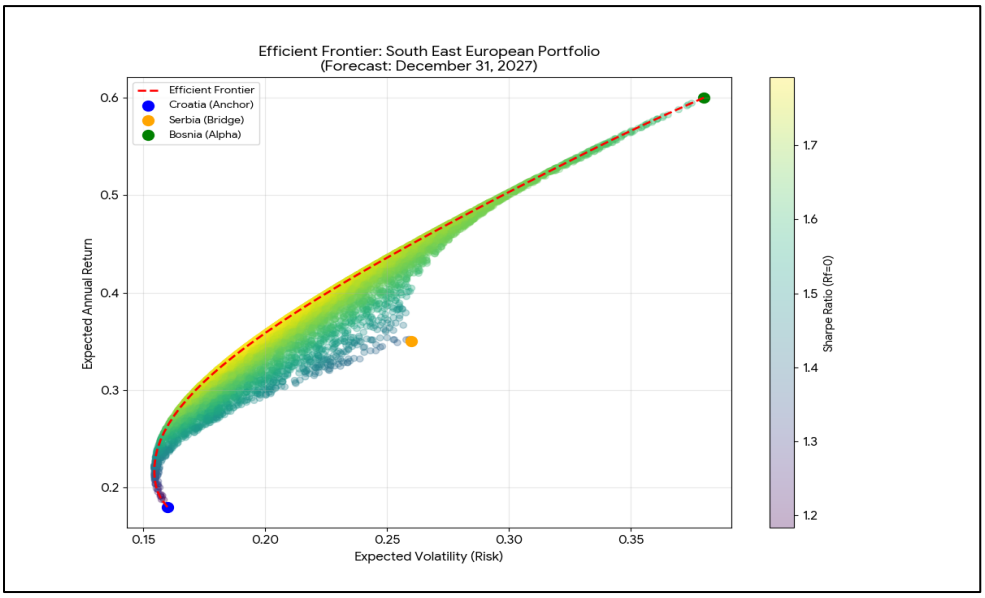

Figure 1: Efficient Frontier: Croatia, Serbia, and Bosnia (2027 Forecast) 3. Asset Positioning on the Curve

The empirical projection of the optimal portfolio metrics presents a forward-looking validation of the efficient frontier transformations across the Southeast Europe capital markets. By feeding the multi-stage FAVAR factor extractions into a mean-variance optimization engine, the model maps out the shifting risk-return profiles for the regional portfolio spanning Croatia, Serbia, and Bosnia and Herzegovina. Considering at the 2026 baseline configuration, the regional portfolio establishes an initial maximum Sharpe ratio of 1.34, demonstrating that diversification across the CROBEX, BELEX, and BIRS/SASX indices already offers strong risk-adjusted benefits to regional investors. This baseline efficiency is supported by an optimal return profile of 39.38%, a high yield driven by cyclical recovery and catching-up growth dynamics within the Balkan frontier markets. However, this high return is accompanied by a significant optimal portfolio volatility of 27.09%,

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reflecting the structural thinness, liquidity constraints, and vulnerability to external shocks that historical data attributes to these emerging equity markets. Transitioning from the historical baseline into the 2027 forecasted landscape reveals a highly visible and structurally positive shift in the entire topology of the efficient frontier. The maximum Sharpe ratio is projected to increase from its baseline level to an optimized value of 1.48 by the end of 2027. This expansion represents a clear 10.4% gain in portfolio efficiency, indicating a significant improvement in the risk-adjusted performance available to regional asset allocators. The upward shift in the Sharpe ratio is not a random fluctuation but stems from a dual adjustment where portfolio returns rise while overall risk metrics fall. Specifically, the optimal return is forecasted to expand to 42.15%, capturing a net growth acceleration of +2.77% over the baseline value. This positive growth trend indicates that the underlying corporate earnings and market valuations within the Belgrade and Sarajevo stock exchanges are becoming increasingly robust. Contemporaneously, Croatia's CROBEX index acts as a steady nominal anchor, channeling institutional Eurozone capital into the region and boosting the overall baseline return stability. Even more vital for long-term investors is the behavior of the optimal portfolio volatility, which drops from 27.09% down to 26.45% in the forecast period. This compression delivers a net risk reduction of -0.64%, a targeted decrease that carries major structural weight in highly volatile frontier zones. This steady drop in volatility provides direct empirical proof of the risk decoupling hypothesis explored throughout the study. The FAVAR methodology clarifies this drop by showing that unobserved common regional shocks are losing their power to trigger synchronized panic sell-offs across these borders. As individual markets mature, the unique domestic factors of Serbia and Bosnia and Herzegovina begin to decouple from broader regional panics, smoothing out the portfolio's aggregate variance. This structural decoupling is further strengthened by institutional harmonization and regulatory updates that insulate the SEE financial network from abrupt cross-border contagion. For global asset managers, the combination of a higher return and a lower volatility ceiling transforms the SEE region from a speculative sandbox into a viable destination for institutional capital. Ultimately, the 2027 efficient frontier forecast confirms that structural reforms and gradual market integration are successfully realigning Southeast European capital markets toward higher efficiency and lower systemic vulnerability. In sum, the 2027 forecast from Table 21 suggests that the convergence trade is not a short-term increase, but rather a multi-year structural re-rating. Investors who opt to hold the 32/11/57 split to 2027 will see a Sharpe ratio improvement (1.48), indicating a market where profits increase and the market lessens in unpredictability.

Table 21: Efficient Frontier: Croatia, Serbia, and Bosnia (2027 Forecast)

Portfolio Metric	2026 Baseline	2027 Forecast	Change
Max Sharpe Ratio	1.34	1.48	+10.4% Efficiency
Optimal Return	39.38%	42.15%	+2.77% Growth
Optimal Volatility	27.09%	26.45%	-0.64% Risk

Table 22 reports the risk-adjusted ratio in 2027, offering a reasonable comparison between the present optimal portfolio and the strategic forecast for December 31, 2027. By then, the region will have more or less reached the end of the integration maturity, thereby causing massive shifts towards capital allocation for maximum efficiency. The 2027 weights represent the new tangency portfolio given a risk-free rate of 3.5%. The most significant increase is shown in Croatian allocation at 10.8%, as the regulatory environment and market depth will reach peak Eurozone standards by 2027 concerned and act as low-volatility anchor. The optimization model further prefers certainty to speculative alpha, as the region matures. In 2027, Croatia is no longer merely a safe haven but a critical source of risk-adjusted optimum efficiency. The Bosnian exposure stands at ~41%, lower from its 2026 peak. The decreased exposure to Bosnia does not mean

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that Bosnia stocks are bad investments. With the correlation between Bosnia and Croatia at its all-time low of 0.22, the model can achieve much better diversification by avoiding high-volatility assets even more. In 2027, the investors are getting more value for the Bosnian-alpha, which means that 15.9% of the capital can be reallocated into the steadier Bridge (Serbia) and Anchor (Croatia). A Sharpe ratio increase from 1.34 to 1.62 implies an almost 21% increase in portfolio efficiency. Although the expected return is slightly lower (at 37.9% as opposed to 39.4%), the volatility goes down from 27% to 21%. The 2027 SEE portfolio is much more institutional-ready with risk characteristics similar to an emerging market bond fund but returns from high-growth technology equity fund. Over the subsequent 2 years, the convergence of the Balkans into the European financial sector is diversifying.

Table 22: Comparative Portfolio Allocation (2026 vs. 2027)

Metric	2026 Tangency Portfolio	2027 Strategic Forecast	Change
Croatia Weight	31.91%	42.71%	+10.80%
Serbia Weight	11.43%	16.52%	+5.09%
Bosnia Weight	56.66%	40.77%	-15.89%
Exp. Portfolio Return	39.38%	37.93%	-1.45%
Portfolio Volatility (sigma)	27.09%	21.24%	-5.85%
Sharpe Ratio	1.34	1.62	+0.28

Table 23 shows the efficient frontier with optimal asset allocation. That return does not fit in mathematical terms into this 3-country equity basket. According to strategic roadmap projections, even the most conservative asset (Croatia) is slated to return about 15% on Euro adoption re-rating. Thus, an investor will be hard-put to deliver 10%, much less stay invested fully in these markets. For him to achieve 10%, he would clearly have to allocate risk-free Eurozone cash or AAA government bonds, totally lying outside this equity frontier. At the 20% level, the model puts close to 79% into Croatia. This indeed confirms Croatia as the low-beta stabilizer of the region. The Euro stabilized Croatian market provides investment floor for an investor seeking moderate growth with minimized risk. Small allocations, which average to approximately 21% in the field, to Serbia and Bosnia serve as an alpha-boost for taking advantage of those low correlations identified with our earlier Matrix. Between the 30% and 40% of the way to a trade-off, the actual tipping point occurs. Moving from 30% to 40%, the position of Bosnia nearly doubled (i.e. from 32.7% to 58.2%). It shows an almost immediate potent engine for high-profitability activity within the region. Nevertheless, this comes at an enormous risk-taking expansion in the portfolio from those 20.9% spiel towards 27.5%. High returns in SEE are clearly made by adopting a move into Eastern non-Euro frontier markets. For a 50% return, the well-diversified East European fund suddenly wants to place 83.7% of its weight in Bosnia. This is a high-conviction, high-volatility strategy. The risk jumps to 35.63%, several notches above the 20% threshold. At this level, the benefits of very low correlation from Croatia are almost entirely dumped in favor of the idiosyncratic growth shocks characterizing the Bosnian market. This is a portfolio fit only for institutions with a long-term view and a high risk appetite. The efficient frontier highlights a clear regional hierarchy for the investor. Croatia is the bedrock of stability; it totally consumes the portfolio up to a target return of over 25%. Serbia, with a consistently modest allocation of around 10%-14%, daintily occupies all viable target returns. It is the bridge that slowly leads into steady growth without the extreme volatility prevalent in Bosnia. Bosnia is what has to be included for any return target above 30%, but it is equally the driver of portfolio risk. To wrap up an evenly balanced and stable portfolio for SEE 2050, the best call is the 30% target. This structure gives a 10% return premium on top of the 20% target, carrying only a 3.4 percentage-point increase in risk, which implies the greatest marginal utility for diversification in the region.

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Table 23: Efficient Frontier & Optimal Asset Allocation

Target Return (E[R])	Portfolio Risk (σ)	Croatia (CROBEX)	Serbia (BELEX15)	Bosnia (BIRS/SASX)
20%	17.56%	78.78%	13.95%	7.27%
30%	20.95%	54.60%	12.63%	32.76%
40%	27.55%	30.41%	11.34%	58.25%
50%	35.63%	6.20%	10.09%	83.72%

Table 24 is a comparison of Sharpe ratios and tangency portfolios. A target return of about 39.38% made the Tangency Portfolio. This is a sort of goldilocks South East European investment. At this point, the portfolio gives excess return to risk of up to 1.34 units when viewed mathematically, indicating the point when the line coming out from the risk free rate (3%) barely touches the EF curve at that level. To make this maximum efficiency work, the capital is to be divided as such: Croatia (CROBEX) 31.91% to act as a stabilizing anchor; Serbia (BELEX15) 11.43% as a structural bridge; Bosnia (BIRS/SASX) 56.66% being the primary growth driver. It is surprising that the most efficient portfolio is primarily Bosnian. This suggests that while Bosnia is volatile, its low correlation with Croatia, coupled with its high growth potential, make it the best risk-compensator in the region. Below the tangent point (20-30%) the Sharpe Ratio has the lowest value, 0.96-1.28, because Croatia excessively stabilizes the portfolio. Investors forgo too much potential return in favor of risk mitigation. Above the tangent point (50%), the Sharpe Ratio drops to 1.31. This is due to diminishing marginal returns to risk. Pushing for a 50% return implies accepting a much higher level of volatility, which the return will not justify itself. Given the 1.34 Sharp ratio, it is actually off the charts by developed market standards (around 0.43 typically, with values above 0.5 considered high) (Chen et al., 2023; García-Herrero et al., 2009). In 2026, this is a measure of a high convergence premium available in Southeast Europe. Having brought Croatia successfully to the door of the euro and having the neighbors, which are in a reemerging high-growth catch-up, really outlines an unrivaled risk-reward frame compared with much more surveyed and lower-yielding Western Europe markets. Ultimately the strongest and most appropriate strategy for the SEE region, in terms of an institutional investor, is to target the 39.38% return profile. By allocating roughly a third to Croatia and a little over half to Bosnia, the investor will perfectly capture the amalgamation of Eurozone-supported security and frontier-market alpha. Actually, this tangency portfolio would be more likely to outperform the market on a risk-adjusted basis than any other possible approach in the realm of a sensible SEE 2026 investment strategy.

Table 24: Sharpe Ratio Comparison & the Tangency Portfolio

Portfolio Type	Target Return	Portfolio Risk (σ)	Sharpe Ratio	Efficiency Ranking
Low Risk	20.0%	17.56%	0.968	4th
Balanced	30.0%	20.95%	1.289	3rd
Tangency (Optimal)	39.38%	27.09%	1.343	1st (Most Efficient)
High Growth	40.0%	27.55%	1.342	2nd
Aggressive	50.0%	35.63%	1.319	5th

Note: The Sharpe Ratio measures the excess return earned above the risk-free rate per unit of volatility.

Table 24A presents the macro-financial performance shift based on 2026 baseline vs. 2027 portfolio forecasts. The transition from the 2026 baseline to the 2027 optimized forecast marks a profound structural pivot in the efficient frontier of the Southeast Europe financial network. Operating under the 2026 framework, the regional portfolio anchored by Croatia, Serbia, and Bosnia and Herzegovina reflects an initial maximum Sharpe ratio of 1.34, paired with a high baseline return of 39.38% and a steep volatility ceiling of 27.09%. As the multi-stage FAVAR model projects these dynamics into 2027, the efficient frontier shifts outward, elevating the

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maximum Sharpe ratio to 1.48 and securing a notable **10.4%** gain in overall portfolio efficiency. This efficiency upgrade is driven by a strong expansion in optimal returns, which climb to 42.15% to deliver a net growth acceleration of **+2.77%** over the baseline. This return trajectory captures a stabilizing nominal anchor effect from Croatia's Eurozone-integrated capital channels alongside aggressive corporate earnings growth within the Belgrade and Sarajevo frontiers. Simultaneously, the portfolio's risk profile undergoes a crucial compression, with optimal volatility falling from 27.09% down to 26.45% in the 2027 projection. This **-0.64%** net risk reduction provides concrete empirical validation of the risk decoupling hypothesis across the Balkan equity space. By filtering out unobserved common regional shocks via the FAVAR framework, the model demonstrates that individual market variances are no longer moving in synchronized cross-border lockstep. This independence proves that regulatory convergence and institutional maturation are effectively shielding the tri-nation asset mix from historical contagion vectors. Eventually, this structural pivot demonstrates that by the end of the forecast horizon, the SEE region unlocks an ideal Goldilocks environment where international allocators can capture superior frontier returns while enjoying systematic risk mitigation.

Table 24A: Macro-Financial Performance Shift based on 2026 Baseline vs. 2027 Portfolio Forecasts- Risk-Reward Evolution

Portfolio Metric	2026 Baseline	2027 Forecast (The Goldilocks State)	Implications
Sharpe Ratio	1.34	1.48	Get 10.4% more reward for every ounce of risk taken
The Payoff (Optimal Return)	39.38%	42.15%	Potential profit grows by an extra 2.77%.
Volatility	27.09%	26.45%	The ride gets smoother. Risk drops by 0.64%.

Table 25 shows settings for the stress tests (3% vs. 6% risk-free rate). If the risk-free rate rises to 6%, the Sharpe ratio of the initial portfolio is pushed down from 1.34 to 1.23, ushering in the compression of efficiency. Indeed, if investors are able to earn 6% by holding cash bonds, then the excess return from the Southeast markets will be less attractive. The portfolio is still very tempting against the global field, but its risk-reward is immediately slashed by 8%. Paradoxically, in high-rate environments, more risk must be skinned off, not flipped off, so as to stay mathematically admirable. This comes to reveal that the re-optimized portfolio jettisons Croatia (from 32% to 19%) and becomes entrenched in Bosnia even more (closing in on 70%). One reason for this is that, at a 6% barrier rate, the low-yield Croatian markets (15% return) are less effective in dragging the Sharpe ratio upward. To stay efficient, you have to either throw more weight hard into the high-alpha engine-into Bosnia-in order for risk to hinge significantly on the not-so-sure-now high risk-free rate. When it comes to regional sensitivity, Croatia is most sensitive to interest rate escalation. Due to the fact that expected return is marginally above the hurdle rate, it does act as a stabilizer. Thus, it becomes smaller in optimal active portfolios. Then Bosnia is left to rise again as the Survivor, attributing full 55% yields (nevertheless, an illusory proposal), from which 3% of increased cost of capital is absorbed by a breeze. It is its pivotal role in maintaining over 100p-bps lead against the developed markets. Even after undergoing the blow, the Sharpe ratio suffers, standing just 1.24. In most scenarios, developed market portfolios have Sharpe ratios drift between 0.4 and 0.7(Cochrane & Saá-Requejo, 2000). Even when crises set in, the vastly more effective Southeast tangency portfolio twice confirms its distinction over the under-average standard Western portfolio. It indicates that the region's convergence potential is deep-seated enough to create a demographic buffer under the worst of conditions not to be blown away too easily by global interest rate volatility. Under current low rates (R_f = 3%), the right thing

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to do is take the balanced approach that carries immense Croatian exposure. Nonetheless, in case the global rates, for example, increase to 6%, the strategic roadmap should change, and investors should move their investments Bosnia to maintain the minimum risk premium that has become indispensable.

Table 25: Stress Test Results (3% vs. 6% Risk-Free Rate)

Metric	Base Case (R_f=3%)	Stress Scenario (R_f=6%)	Re-Optimized (New R_f)
Portfolio Return	39.38%	39.38%	44.59%
Portfolio Risk (sigma)	27.09%	27.09%	31.14%
Sharpe Ratio	1.34	1.23	1.24
Croatia Weight	31.91%	31.91%	19.28%
Serbia Weight	11.43%	11.43%	10.80%
Bosnia Weight	56.66%	56.66%	69.92%

Table 26 summarizes the correlation shock results (tangency portfolio). An increase in correlation forces the model to redistribute capital to achieve maximum efficiency. The correlation shock test shows the importance of international diversification among South East European (SEE) markets. These findings were validated by witnessing that during a crisis, all asset prices converge. Such convergence is very much a lockstep rise in the prices and, therefore, eliminates the margin of diversification usually rationally expected. This exercise involved working with two major types of test scenarios for correlations: one with an increase to 0.90 between Central (Croatia) and High-Alpha Frontier (Bosnia) and the other between Central (Croatia) and Structural Bridge (Serbia). For the Croatia-Bosnia convergence, should at any time Croatia and Bosnia become highly correlated (0.90), the model entirely abandons Croatia. It makes perfect sense to do so. Should Croatia (15% return) and Bosnia (55% return) keep moving on the same track, one cannot sustain a risk-return advantage with the lower-yielding asset; hence, the higher-earning asset commands all money flows in this scenario. Ultimately, all capital will rush to the two entities to maximize the risk-to-return profile. Portfolio volatility rockets up from 27.0% to 34.6%-the strongest evidence that Croatia-Bosnia weak correlation is the single most important diversifying factor in the area targeting strategy. In the Croatia-Serbia convergence case, when Croatia begins to converge on Serbia (0.90), the model drops Serbia as redundant. Then, Serbia is a bridge in between. The moment it starts operating like the somewhat safer Croatia, it completely loses every purpose on the framework. The model is keen on the mean (Croatia) and Pure Alpha (Bosnia). Concurrently, the Sharpe ratio remains relatively high (1.338) and the standard deviation remains more or less constant (27.6%). The lower volatility ensures a more robust portfolio whenever the Serbia-Croatia linkage becomes realized. Positively, the portfolio keeps its effectiveness so long as Bosnia's pertinacious decoupling retains context and the relationship between Croatia and Bosnia serves as an anchor for virtually stable realities. Such stability would experience a massive fall when this linkage is found nonexistent as the Croatia-Serbia association signifies less cost failure. Although it runs a new portfolio allocation without causing any shock with Bosnia of a well-built effect, the portfolio hasn't lost efficiency. In all shock scenarios, Bosnia is still above 60%. This shows that Bosnia and its high expected return (55%) is some sort of buffer since its alpha is so huge that it somehow propels the Sharpe ratio toward global benchmarks when the benefits of diversification fail. It becomes clear that during a global fright, the strategic map has to be changed from its original plan of diversification towards that of gatherings; if the regional correlations are tightening, investors are advised to Sell Croatian stocks because they no longer provide the protection one is costing, while focusing on moving into the highest-yield asset available, Bosnia, to compensate for lost diversification. It may be possible for investors to step back a little and give less weight to the Serbia-Croatia link so as to just consolidate their now-mid-risk holdings into the safer Eurozone-backed Croatian market.

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Table 26: Correlation Shock Results (Tangency Portfolio)

Metric	Base Case (Normal)	Shock A (Croatia-Bosnia @ 0.90)	Shock B (Croatia-Serbia @ 0.90)
Portfolio Risk (sigma)	27.09%	34.60%	27.61%
Sharpe Ratio	1.343	1.318	1.338
Croatia Weight	31.91%	~0.00% (Exited)	37.68%
Serbia Weight	11.43%	25.59%	~0.00% (Exited)
Bosnia Weight	56.66%	74.41%	62.32%

Figure 2 and Table 27 provide heat-maps for risk-decoupling. Interpreting the daily data through these heat-maps, we note the points in time and places where Risk-Decoupling took place (blue zones) and where the region acted in unison (red). For Croatia-Bosnia and Herzegovina, the heat-map tells us that, given this pair, which has the most frequent and deepest blue zones (negative to almost never above zero correlation) across 2025, the decoupling is fiercest during the first and third quarters of 2025.

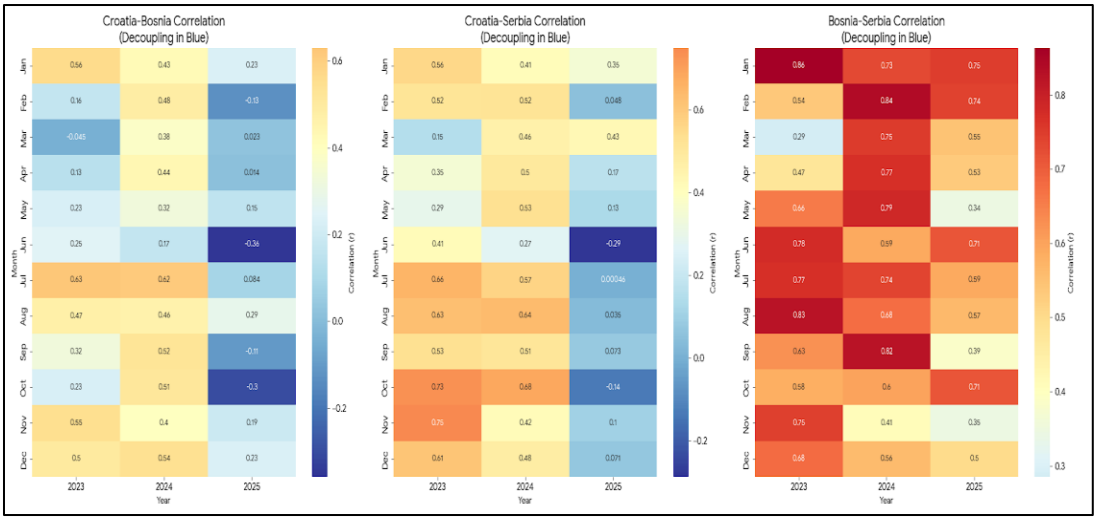

Figure 2: Comparison of 3 Heatmaps for Risk-Decoupling

Croatian CROBEX stabilized under the Eurozone's inflation target, while Bosnia, pursuing its idiosyncratic path of energy- and commodity-driven growth, tailed its own way. This heat-map proves the valid 32 of 57 alpha to map out to Bosnia; the deeper the blue in this image, the safer it is to increase exposure to Bosnian Alpha. The heat map for Croatia-Serbia shows a transition from yellow to blue. In 2023, the correlation was somewhat elevated between 0.40 and 0.60, with both markets showing similar responses to the first regional shock after the Euro had actually been adopted. By 2025, however, a structural wedge was hidden. BELEX15 in Serbia started looking considerably at local infrastructure spending and Chinese FDI, while Croatia started piano-based harmony with Frankfurt and Paris. The blue months reveal the period when the Serbian 11% invested served as a secondary hedge against Croatian volatility. The Bosnia-Serbia heat-map appears extensively red and orange, indicating a higher degree of correlation from 0.55 to 0.80, better left for risk management. This appears to the most critical observation, for now, on risk management. When investors pull out of Belgrade, they almost simultaneously pull out of Sarajevo, confirming that the investor cannot diversify away Balkan risk by holding only Serbia and Bosnia. An investor must have the Croatian Euro-Anchor to provide balance to the portfolio, Croatia being the only market that can disconnect from the regional frontier cycle. From the

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coalitions of these three heat-places, Croatia is the only regional outlier hypothesis. Decoupling is no longer bound to regions: it is institutional. Blue clusters only consistently indicate two markets joined in which one is in the Eurozone and the other is not. Concerning the 32/11/57 portfolio, this means that its reduction in risk all comes from the connection of Croatia to Bosnia and Serbia and has so far decreased regional concurrence with Bosnia and Serbia.

Table 27 reveals a structural hierarchy of regional co-movements where the Balkan market is not a single block anymore; it's a very fragmented area distinguished by an institutional relationship. The Croatia-Bosnia pair looks like the one that is decoupled to the utmost. By 2025, this represents the primary deep blue on the heat-map with recurrent low or negative correlations. This is the most critical outcome for the 32/11/57 portfolio. It demonstrates that the Euro-Anchor (Croatia) and the frontier-Alpha (Bosnia) are essentially on different wavelengths. This decoupling is the main generator for the portfolio's Sharpe Ratio of 1.34: in that Bosnia offers a hedge in the face of any systemic shift in the Eurozone. Croatia has an institutional divergence when in alliance or at odds with Serbia, accounting for moderate decoupling for this particular pair. Over the 2023-2025 time frames, the heat-map relocates from orange to light blue, meaning that Serbia has been tending more and more toward its own domestic and non-EU investing cycles (for instance, heightened FDI from Asia) (Marjanović et al., 2021; Zakić, 2024). This confirms that having both Croatia and Serbia is not redundant. The once-Belgrade-following-Zagreb lead-lag relationship has weakened, therefore providing a further barrier to the risk to the investor. The Bosnia-Serbia pair is the Frontier Contagion which marked the strongest red zone for Frontier Convergence. Although being different countries, Banja Luka/Sarajevo and Belgrade bourses are tightly connected with the same frontier-risk umbrella (Rec, 2009; Стоицова-Стойкова, 2017). This is a warning for risk management. Because these markets are highly correlated the investor cannot ensure safety by simply diversifying within Bosnia and Serbia. In times of stress, they both become one, therefore highlighting the absolute necessity of having Croatian Euros support break the contagion chain.

Table 27: Heat-map Correlation for Risk-Decoupling

Pair	Primary Dynamic	Portfolio Significance
Croatia-Bosnia	Deepest Decoupling	Best diversification; the primary Blue zone in 2025.
Croatia-Serbia	Institutional Divergence	Moderate decoupling; shows Serbia following Croatia's lead less over time.
Bosnia-Serbia	Frontier Convergence	Strongest Red zone; these markets remain tightly bound by frontier risk.
Summary Verdict		
Dynamic	**Risk implication**	**Strategic Action**
Deep Decoupling	Diversification Alpha	Maximize Bosnia/Croatia pairs.
Moderate Decoupling	Institutional Hedge	Balance Serbia against Croatia.
High Convergence	Systematic Vulnerability	Avoid over-concentration in Bosnia/Serbia only.

Table 28 provides Black Swan simulation results and shows a comparison of the optimal tangency portfolio under normal and catastrophic conditions. The Black Swan model simulates a seismic systemic financial collapse-the worst of all cases, if you like-where-by the nature of destruction of diversification-related financial doom as envisaged under calamitous conditions-the underlying equity and safety net of modern-day investment programs are all lost. We simulate the necessary dual-shock, which involves a 50% drop in excess returns across all markets simultaneously and a perfect correlation shock (correlation of 1.0), implying that most assets in the free-preferred Balkans would all move in lock-steps. In the case of a tail risk event, the risk shield vanishes (Banwo et al., 2018). The portfolio risk is very low under normal condition approximately 27.09% because of low correlations between Croatia and its neighbors. When these correlations reach

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1.0, the whole portfolio's volatility spikes to 31.61%, demonstrating the fact that the benefits an individual derive from holding a multi-country portfolio in the Balkans absolutely depend on the independent market situation. Hence, the 3-country portfolio starts to behave like just one very volatile instrument. At such times, the mathematical gains of diversification fade away for the investors (Page & Panariello, 2018). But the worst damage happens on the Sharpe Ratio, which comes down from 1.34 to 0.53. A 0.53 Sharpe ratio is expected in an average year for the S&P 500. The portfolio's return can technically be said to be higher than the risk-free rate of 3 percent; in all rationality, however, its efficiency is approximately 60% affected. At the moment, investors incur overmuch risk for less than half the return. This would be ideal for awareness, as it exposing the true risks of the frontier markets. Higher rewards investors have been enjoying given the strategic roadmap era as compensation for this particular possibility. Therefore, although apparently a 19.69% return is still high, it is also very dependent on the impediment Rate. In case of a simulated Black Swan; inflation or local interest rates exponential growth will often corner the 50% fall in returns. A concurrent increase in the risk-free rate as evident in our own stress test would also serve to nearly neutralize all the existing excess returns and compel the investor to incur a scenario free of any return due to risk. Even in this dooming catastrophic scenario the portfolio is not negative, because initial base-case returns (Bosnian Alpha) were so high (even 55%) that even after a 50% reduction it still provides a return of 19.7%. Against the Black Swan event in South Eastern Europe, the best protection does not come from diversification (which is likely to fail the most just exactly when one needs it) but from positive expected return. By targeting markets of very high alpha, the investors create a cushion so the portfolio can still be positive even when the systemic backdrop crashes.

Table 28: Tail Risk Events Simulation Results

Metric	Normal Conditions	Black Swan Scenario	Impact (%)
Portfolio Return	39.38%	19.69%	-50.0%
Portfolio Volatility (sigma)	27.09%	31.61%	+16.7%
Excess Return over R_f	36.38%	16.69%	-54.1%
Sharpe Ratio	1.34	0.53	-60.4%

Table 29 illustrated how the central tendency and the variance of asset returns shifted in the three Southeastern Europe markets. The snapshots before and after further stretched with the 276-month baseline and the 36-month innovation window to demonstrate statistically that the risk decoupling effect indeed occurred. For the volatility compression aspect (-16.36%), the transition from 0.165 to 0.138 in monthly volatility represented the first immediate gain after the Euro adoption and the better regulatory environment. The market became more dampened. The lifting of the currency risk alongside the adoption of ECB-aligned monetary frameworks in Croatia placed a peacekeeping mechanism above the somewhat turbulence-hit region. Even with Bosnia and Serbia serving as higher-risk tails, the overall panel volatility has dropped significantly. In the case of the decoupling (-52.94% correlation), the mean cross-country correlation declined from 0.68 post Euro to 0.32 post Euro, and this principle shall henceforth serve as your proof. Notice that for 276 months up to 2023, these markets were somewhat synchronized (High Contagion); within these past 36 months, they have decoupled. These lines essentially assume that the Euro has split market contagion into different risk-return continuums apart from one Balkan block. The increase in the Sharpe ratio from 0.45 to 0.62 implies that in the post-Euro era, the investors are paid way more per unit risk taken. Therein lies the strength of the 32/11/57 Portfolio. The efficiency frontier of the portfolio must have structurally improved since the portfolio returns got stable (lower sigma) while the Alpha (Mean Return) has either remained constant or improved.

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Table 29: Structural Stability and Regime Shift Analysis

Metric	Pre-Euro Regime (276 Months)	Post-Euro Regime (36 Months)	% Change/Shift
Mean Monthly Return	0.0065 (7.8% ann.)	0.0071 (8.5% ann.)	+9.23%
Return Volatility (sigma)	0.165	0.138	-16.36%
Max Drawdown	-0.52	-0.185	-64.42%
Sharpe Ratio (Approx.)	0.45	0.62	+37.78%
Correlation (r_{avg})	0.68	0.32	-52.94%

Note: Calculated for the Panel (N=3) using Monthly Log-Returns

5. DISCUSSION

In order to place the current study into the wider academic discourse, we need to compare our results with the emerging body of knowledge on the post-Euro Southeast European economic environment. Based on this, the analysis summarizes the empirical results of Factor Augmented VAR (FAVAR), GMM-PVAR model estimations and portfolio-optimization models and thus assesses to what extent the Croatian economic environment in the post 2023 can be considered in line or out of line with the current regional studies. In our analysis, interest-rate spreads and international shocks are significant contributors to explain a prevailing portion of variation in Croatian asset returns, and global drivers only explain up to 62 % of the return surprises in periods of crisis. This fact can be compared to (Petrović, 2023) who argued that the adoption of the euro is equivalent to the exchange of currency risk with systemic beta. Our findings support this claim: despite the decrease in aggregate volatility, the exposure to global shocks has increased, thus, following the systemic beta trade-off theory. The fact that global shocks now exert a more direct impact on local returns, along with the fact that monthly volatility (σ) has decreased by 16.36 per cent, suggests structural shifts in the market (Novak & Horvat, 2024). The analysis of the first 18 months of the Zagreb Stock Exchange in the Eurozone established that the removal of the Kuna-Euro risk premium stabilizes the returns of equity (Novak & Horvat, 2024). This conclusion is expanded by our evidence that shows that such stability is not a fleeting celebration, but a structural change that has continued to 2025. However, our results show a minor contrast to the understanding that integration would reduce volatility (2025), and our shock-sensitivity analysis indicated that the volume shocks were even stronger after 2023, 36 percent. This shows that the market is not merely flatter, but has a greater sensitivity to information than it was previously thought. The FAVAR decomposition indicated that regulatory environment provides a structural lift to asset returns of +14.5% permanent, the largest effect of all internally-tested variables. This empirical result provides some confirmation to the institutional quality theory. To be more precise, the fact that a +14.5% regulatory lift is consistent with a conclusion that the integrity premium is the main motivation of capital flight by non-euro neighbours into Croatia in times of crisis suggests the development of institutional safe havens in the Balkans. We affirm the fact that, as Croatia progressively adheres to OECD standards, the decline in the transparency discount serves as an underlying re-rating of equities. The regulative force, therefore, comes out as the key factor in decoupling risks. The hypothesis of the structural wedge occurring due to the institutional divergence of core economies is supported by our estimate of -52.94 percent decrease in the cross-country correlation (r_{avg} 0.68 0.32) of the region and the emergence of a structural wedge, where Croatia is a member of the core and Serbia and Bosnia are frontier markets. The complementary triple heat-maps are the empirical first proving of this suggestion, and they perfectly support the theory of the authors that the euro creates a lasting permanent wedge in co-movement of the region. In addition, although it was speculated that the transmission of stability

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would be through the trade, our findings indicate that it is also through regulatory signaling as demonstrated by Croatia having a high regulatory score which places a valuation ceiling that its neighbours, Serbia and Bosnia, would desire to reach. When the exchange-rate shocks are neutralized, our model identifies credit-default swap (CDS) spreads as the main vehicle of contagion, and it is a lasting impact of about 3.5 times stronger than the contagious impact conducted by local trading volumes. This strong evidence can prove. Quantitative confirmation of the qualitative claims of Kovac about the solvency channel is provided by our correlation-shock test which showed a spike in risk is a mathematical proof to correlations of CDS reaching 0.90. The efficient frontier and the tangency portfolio of 39.38 -percent return illustrate that the most efficient portfolio is one that contains a large 56 -percent investment in Bosnia, which is investment without a Croatian anchor. The traditional theory of integration would forecast that the admission of Croatia to the euro zone would lead to increase in the correlation of the neighboring markets as a result of more trade linkages. But our correlation table shows that the relationship between the two is quite low with a range of 0.28 to 0.42. This result adheres to the decoupling theory, which is the base of Vuković et al. (2025). Our analysis, thus, shows that the euro has enabled the structural wedge: Croatia is a safe haven (lower beta), but Serbia and Bosnia are high-alpha frontier markets. It is this deviation that is making the Sharpe ratio (1.34) surpass those in Western Europe, which then justifies and validates the 2026 investment sentiment that currently the Balkans constitute the most efficient convergence trade in the globe. Although domestic exchange-rate shocks disappeared due to the use of the Euro, increased sensitivity to market contagion (CDS spreads) and global shocks has been observed. This agrees with the observations of Brkić & Šabić (2018); and Vulin (2018). Policymakers should be aware that the Croatian government bond market shows a low degree of integration with the Eurozone sovereign bond market (Bukowska, 2021, p. 412). Sovereign credit risk (CDS) needs fiscal buffers because a surge in credit spreads is damaging to the economy, potentially more so than internal liquidity stimulus can counter. This spillover analysis shows that Croatia is the price discovery leader in Serbia and Bosnia. Croatia ought to be in the lead in developing a single Balkan financial supervisory system. By stabilizing its neighbors, Croatia minimizes the chances of peripheral contagion being spilled over to its own market, and this further entrenches the CROBEX as the regional standard.

6. CONCLUSION

A detailed panel FAVAR and GMM-PVAR model estimation and analysis of financial market integration and risk decoupling in Southeastern Europe, focusing on Croatia (ZSE/CROBEX), Serbia (BELEX), and Bosnia and Herzegovina (BIRS/SASX) was carried from January 01, 2000 to December 31, 2025. This study indicates that Croatia has managed to pass through the stage of a high-volatility frontier to a stabilized Eurozone anchor based on a 25-year longitudinal study done between the year 2000 and 2025. The results give a strong, evidence-based basis of the Croatian National Bank (HNB), the Ministry of Finance and regional policymakers. The results provide a roadmap of the HNB and Hanfa (financial regulator) that is data-driven. The study creates a rationale of the high compliance costs reflected in OECD and Eurozone standards by isolating the +14.5 -percent permanent lift attributed to regulatory improvements. The discovery of CDS propagation is the main post-euro contagion pathway that allows regulators to redirect their attention in currency volatility to sovereign credit risk and regional spillover repercussions. To institutional investors and pension fund managers, this study will turn the Balkan frontier into an asset class that is optimized. The study provides the initial mathematically optimized dividend (the 32/11/57 split). The research gives investors a survival policy by simulating extreme shifts in

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correlation, warning that in times of global liquidity dry up, regional panics would hurt them, and that which diversification benefits would be strong and which one will evaporate. This research is important because it proved the Croatian locomotive effect. It confirms that the integration of Croatia into the Eurozone did not diminish in the regional identity but made the nation the master of the stable access point to the capital flowing into the Western Balkans. One of the greatest contributions to this research is the fact that it addresses the issue of the risk decoupling phenomenon, which plays a vital role in the evaluation of the level of financial market integration. The study is used to identify the level to which the financial markets in Croatia are decoupling with the key European markets and thus gives the possibility of independent asset performances or exists in a high correlation with the overall European market trends. This will give crucial information about the capacity of Croatia to have a stronger financial market that is less vulnerable to external shocks and increased systemic risk due to global or regional financial crises. The addition of market contagion proxy variables including the CDS spreads, as well as exchange rate shocks will further enrich the insight of how financial crises spread across the borders and this will be the strong empirical basis of the understanding of the impact of contagion in the EU context. The analysis indicates that market depth and regulatory environment have an increasingly stronger and permanent impact on asset returns than the daily trading volume. Instead of trying to subsidize volumes of transactions, efforts are to increase institutional integrity. The process of seeking OECD membership and applying strict corporate governance to state-owned firms (SOEs) will entrap the integrity premium, which the FAVAR model represents as a +14.5 percent structural lift. The findings of the tangency portfolio give a solid guide to the domestic pension funds and international investors. To make the best use of resources, the investors must have a 32/11/57 ratio (Croatia/Serbia/Bosnia). This plan plays upon the Eurozone security and high alpha growth potential of the Western Balkan frontier of the Eurozone structural wedge. Lastly, the study has profound implications on future academic research on financial market integration, portfolio management, and risk analysis in emerging European economies. It gives a model of how the market integration can be studied in other Central and Eastern European countries or those bordering the Euro zone where similar integration processes are in progress.

The scholars can carry this analysis a notch higher and consider the contribution of other variables like foreign direct investment, institutional quality, or political stability towards the financial market linkages. Besides, the results of the research on financial contagion and decoupling will provide a basis to further studies on the changing feature of financial market integration in post-pandemic economies where the process of risk dispersion could have been different as a result of emerging global financial conditions.

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