Examining the Military Spending Economic Growth nexus in the presence of Informality: Evidence from the Balkan peninsula

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Abstract

This paper examines the military expenditure (*milex*) economic growth nexus, in selected Balkan and peripheral countries from 1990 to 2022, considering the presence of informality within an institutional framework. Specifically, we employ Principal Components Analysis (PCA) to formulate an index of informality and use the Dynamic Ordinary Least Squares (DOLS) and Fully-Modified Ordinary Least Squares (FMOLS) methods to identify the long –run equilibria. To provide a more comprehensive insight, the study also incorporates two types of causality tests—Dumitrescu–Hurlin and Juodis et al.—to determine the direction of the relationships. Our findings indicate that in the long –run *milex* can be detrimental to economic growth whilst informality boosts it.

Keywords: Economic growth; military spending; informality; Balkan peninsula

JEL Classification: C23, H56, O40, E26, O17

Declarations of interest: none

Introduction

What is the relationship between military spending (*milex*) and economic growth when informality[1] is considered? Security, informality and economic growth represent critical concerns for all countries (Heintz, 2012; Azam and Feng, 2015) with informality being extensively debated due to its nature, measurement, data availability, and its intricate effect on countries' economic growth (Williams 2019; Dell'Anno, 2022). This paper aims to address this question using FMOLS and DOLS estimators for selected Balkan and peripheral countries from 1990 to 2022.

Despite extensive research on *milex* and the shadow economy individually, their interaction and impact on economic growth received less attention. Since Benoit's (1978) work, studies have explored *milex's* effect on various macroeconomic indicators, with mixed findings on its effect on economic growth (see for instance: Dimitraki and Emmanouilidis, 2023; 2024). Some argue *milex* boosts growth via the Keynesian multiplier effect, while others highlight its negative opportunity costs and links to corruption (Aizenman and Glick, 2006; Matthews, 2019). The literature on the shadow economy addresses its size, drivers, and implications, highlighting tax and social security evasion, weak institutions, and corruption as key factors. In developed countries, tax and social security evasion are predominant issues, while in developing countries, institutional corruption and adverse economic conditions are more significant (Friedman et al., 2000; Schneider and Williams, 2013; Dell'Anno, 2022).

However, the relationship between *milex* and the shadow economy remains niche, with limited empirical evidence. For example, Tran (2024) finds that increased *milex* expands the shadow economy in Asian countries, while Goel and Saunoris (2014) suggest larger *milex* correlates with smaller shadow economies due to greater centralization. Conversely, Fedotenkov and

[1] Informality lacks a single definition and is often described with terms like shadow, hidden, or underground economy (Heintz, 2012). In this paper, we follow Hart (2008), defining it as economic activities that occur outside bureaucratic public and private sector frameworks and are not compliant with government regulations.

Schneider (2018) report a positive relationship between *milex* and the shadow economy in Central and Eastern Europe. Bahmani-Oskooee and Goswami (2006) also provide evidence that higher *milex* leads to higher black-market premiums. Sazvar and Nasrollahi (2022) contribute to this understanding by emphasizing regional dynamics and corruption levels. As such, understanding this relationship is crucial for policymaking, as *milex* can impact economic growth and the shadow economy both positively and negatively, depending on factors such as government efficiency and regional dynamics (Schneider, 2011).

However, the previous literature typically examines *milex* as an explanatory factor for informality, while overlooking informality's impact on the *milex* -economic growth nexus. As such, our paper makes two key contributions: first, it bridges the literature on the *milex*-economic growth nexus with informality; second, it empirically generates a new measurement of informality based on Abu Alfoul[2] et al. (2022).

The selected countries constitute a geopolitical, vulnerable, and at times, unstable European super–periphery marked by political unrest, economic disparities, high levels of informality (Fig. 1[3]), and *milex* (Fig. 2) (Kalaš et al., 2021), potentially influenced by their institutional frameworks (they have undergone a multitude of institutional and socioeconomic and political changes during the last few decades (Veremis, 2015)). Though, the borders of the Balkan Peninsula are contested. Our country selection integrates geographical, historical, and political factors, as discussed by Toynbee et al. (1915), Gianaris (1996), Glenny (2012), and Veremis (2017).

[2] Abu Alfoul et al. (2022) identified a list of 10 robust factors of informality based on results from Extreme Bounds Analysis (EBA) (they are: inflation, monetary freedom, time to start a business, internet users, property rights, poverty, corruption, bureaucracy quality, law and order, and internal conflict). We also added government stability to capture political turnover as institutional settings are influenced by the political environment (Elbahnasawy et al., 2016).

[3] For comparison with the established indicators of informality, see Figure i (appendix), with data from Elgin and Oztunali (2012) (updated by Elgin et al., 2021), and Medina and Schneider (2019); and Fig. ii for the evolution of *milex*, informality and GDP growth for the individual countries in our sample.

[Fig. 1 and 2 around here]

Prior literature emphasizes the pivotal role of institutions in regional inequalities, *milex*, and the size of the informal sector (e.g., Feige, 1997; Dreher et al., 2009; Schneider, 2010; Compton and Paterson, 2016; Chen et al. 2020; Abu Alfoul et al., 2022; to name a few). North (1990, p. 3), identifies institutions as "the rules of the game in a society", including both "formal" rules such as constitutions and laws enforced by the state, and "informal" constraints such as "codes of conduct, norms of behaviour, and conventions", which are generally enforced by the members of the relevant group (ibid, p. 36). Institutional theory offers a valuable framework for understanding the relationship between *milex*, the shadow economy, and economic growth (Baumol, 1990; North, 1990; De Soto, 2001; Baumol and Blinder, 2008). It emphasizes the role of formal and informal institutions—like laws, regulations, and cultural norms—in shaping economic behaviour and outcomes, noting that overregulation can push people into the informal economy (Joo, 2011). When examining the *milex* -economic growth nexus within the context of informality, it is essential to consider the role of institutions, which are among the driving forces for informality (Kanniainen et al., 2004). Institutional economics suggests that low institutional quality fosters informality, often due to lower labour costs in the informal economy compared to the formal sector (Schneider and Enste, 2000). Therefore, we approach informality through the lens of institutional settings[4], employing both formal and informal institutional indicators to measure it, as outlined by Iacobuta et al. (2022) (particularly in developing and transition economies as our sample).

Weak institutional frameworks, characterized by ineffective governance, pervasive corruption, and inadequate legal and regulatory systems, significantly contribute to the prevalence of the shadow economy. Institutional factors like property rights, contract enforcement, and the rule

[4] Informality arises when there is a misalignment between a society's formal institutions (laws and regulations) and informal institutions (norms and values creating unwritten rules) (see Polese and Morris, 2015).

of law are crucial for the effectiveness of government interventions and the impact of *milex* on economic growth. In developing countries, weak institutions facilitate shadow economy activities, which impede growth, exacerbate income inequality, and reduce public revenue by entrenching informality (Tanzi, 1999; De Soto, 2001; Darwanto, 2018).

The rest of the paper is as follows: section 2 describes the data and data sources, section 3 provides the methodology and analysis whilst section 4 concludes the study.

Data

We use data from nine Balkan and peripheral countries—Albania, Bulgaria, Croatia, Greece, North Macedonia, Romania, Serbia, Slovenia, and Turkey—covering 1990-2022. Data sources include the World Bank for GDP, government spending, population, investment, secondary school enrolment, trade openness, inflation, internet usage, and time to start a business; SIPRI for *milex*; the Heritage Foundation for property rights, poverty, and monetary freedom; and the International Country Risk Guide (ICRG) for internal conflict, corruption, rule of law, bureaucratic quality, and government stability. Summary statistics are in Table 1 and definitions in the Appendix.

[Table 1 around here]

Methodology and Results

In our empirical analysis, we employed a panel growth approach based on a Barro-type growth specification (as reformulated by Aizenman and Glick, 2006; and Compton and Paterson, 2016).

$$Y_{it} = \alpha + \beta_1 Milex + \beta_2 Informality + \beta_3 Milex * Informality + \gamma' X_{it} + \eta_i + \varepsilon_{it} \quad (1)$$

where for country *i* at time *t*: Y is the growth rate of GDP, informality is an index created by employing PCA[5] in a set of 11 variables (capturing both formal and informal institutions), interaction term (*milex**informality – to capture informality's moderating effect), X is a set of standard control variables cited in the literature, η is an unobserved country-specific fixed effect and ε is the error term.

In this study, we employed both the Fully Modified Ordinary Least Squares (FMOLS) and Dynamic Ordinary Least Squares (DOLS) estimation techniques. FMOLS, initially proposed by Phillips and Hansen (1990) for time-series modelling, is designed for efficient, unbiased parameter estimation in cointegrated systems and is reliable even for small sample sizes. On the other hand, the DOLS estimation method has been shown to outperform FMOLS in estimation accuracy. This is particularly because DOLS accounts for correlations among regressors (Kao and Chiang, 2004) and accommodates mixed integration orders, allowing their incorporation into the cointegrated framework, thus providing asymptotically efficient estimates (Lustrilanang et al., 2023). Furthermore, both FMOLS and DOLS are efficient in handling endogeneity, minor sample bias problems, cross-sectional dependence and slope homogeneity and thereby allow for standard normal inference (Kao and Chiang, 2001; Pedroni, 2004, Tran et al., 2022).

Considering that a panel FMOLS estimator for the coefficient β of model 1 was:

$$\widehat{\beta_{NT}} * -\beta = \left(\sum_{i=0}^{n} \hat{L}_{22i}^{-2} \sum_{t=1}^{T} (\chi_{it} - \overline{\chi}_{\imath})^2\right)^{-1} \sum_{i=0}^{n} \hat{L}_{11i}^{-1} \; \hat{L}_{22i}^{-1} (\sum_{t=1}^{T} (\chi_{it} - \overline{\chi}_{\imath}) \mu_{it}^{*} - T\hat{\gamma}_i \quad (2)$$

Where:

$$\mu_{it}^{*} = \mu_{it} - \frac{\hat{L}_{21i}^{-1}}{\hat{L}_{22i}^{-1}} \Delta\chi_{it}, \hat{\gamma}_i = \hat{\Gamma}_{21i} \widehat{\Omega}_{21i}^{0} - \frac{\hat{L}_{21i}^{-1}}{\hat{L}_{22i}^{-1}} (\Gamma \wedge_{22i} + \widehat{\Omega}_{21i}^{0}), \quad (3)$$

and $\hat{L}_i$was the lower triangulation of $\widehat{\Omega}_i$.

[5] The index is based on the first principal component, with PCA results available upon request.

The DOLS estimator has the same asymptotic distribution as that of the panel FMOLS estimation derived by Pedroni (2001).

Before analysing panel data, it is essential to check for cross-sectional dependence (CD hereafter) using the test developed by Pesaran (2021). CD can result from spatial effects, spillovers, or unobserved common factors, and it is often wrongly assumed that error terms in cross-country panels are independent. Ignoring CD can lead to inconsistent estimation errors (Chudik and Pesaran, 2012). As such and prior the detection of unit roots, we tested the CD in our sample which might result from similar economic and political shocks, or economic integration. Ignoring CD may significantly affect the residuals, leading to inefficient estimates' validity (Pesaran, 2021). The results reveal the presence of strong CD among the variables (Table 2). Thus, we employ both first and second generations panel unit root tests (the Im, Pesaran and Shin (2003), the Maddala and Wu (1999) and the Pesaran (2007) CIPS tests) and our findings confirm that our variables are stationary at first difference (Table 3). These results imply that a long–run co–integrating relationship among the variables used in our analysis is possible.

We also employ Pedroni's (2004), Kao's (1999), and Westerlund's (2005) residual cointegration tests (Table 4) to examine long –run relationships. Our findings confirm cointegration at the 5% significance level, and we estimate the long –run coefficients using panel FMOLS and DOLS (Pedroni, 2001).

[Table 2, 3, 4 around here]

Our findings show that *milex* negatively affects economic growth (crowding-out effect), aligning with D'Agostino et al. (2017) and Azam (2020), as *milex* is largely unproductive in developing countries (Table 4). Investment, trade openness, and government spending positively impact growth, consistent with Žarković et al. (2024). However, secondary schooling negatively affects growth, likely due to an educated workforce moving into low-

productivity sectors and prioritization of *milex* over education in post-socialist, conflict-affected countries (Erić, 2018). Population (as a labour proxy) also shows negative effects, likely due to weak labour regulations and institutions (Kovtun et al., 2014). Informality positively affects growth, as nearly 40% of production in developing and transition countries occurs underground with limited government control and inefficient institutions (Medina and Schneider, 2018)[6]. This can boost competition and efficiency in the formal sector by enabling cheaper outsourcing, production, fast investment multiplier, and easing regulations, thereby promoting growth. The results suggest that the sampled countries have larger informal sectors, consistent with findings by Williams (2006), Bovi and Dell'Anno (2010), and Goel et al. (2017). Finally, the interactive term shows a negative effect suggesting the detrimental impact of *milex* is amplified in environments characterized by high levels of informality and poor institutional quality. This insight can inform policy by indicating that such countries might face greater economic risks from increased *milex*. Noteworthy, that for some estimators DOLS differs from FMOLS due to reduced degrees of freedom from including lags and leads (Kao and Chiang, 2004).

Lastly, we employed two improved tests for panel Granger non-causality, the Dumitrescu and Hurlin (DH) (2012) and Juodis et al. (JKS) (2021). The DH causality test accounts for heterogeneity and cross-dependence, producing robust estimates for small data, though JKS outperforms it in terms of power. The results, presented in Table 5, confirm a unidirectional causal relationship from *milex* to informality suggesting that policies targeting *milex* may also impact informality as in the long –run informality has the potential to transform institutions that are essential for factor accumulation (Goel et al., 2019).

[6] The negative effect of *milex* and the positive effect of informality on growth persist even after addressing outliers through winsorizing and excluding Greece and Turkey from the sample. These findings remain robust when substituting the informality index with the one developed by Elgin et al. (2021). Detailed results are available upon request.

[Table 5 around here]

Conclusion

This study uses FMOLS and DOLS estimators to analyse data from selected Balkan and peripheral countries (1990–2022) to explore this dynamic. While previous studies have examined *milex*'s direct impact on macroeconomic indicators, they often overlook informality's moderating role. The relationship between *milex* and economic growth becomes more complex with the presence of informality. Our findings reveal that informality positively influences long –run economic growth, but its interaction with *milex* generally has a negative effect. Specifically, while *milex* may stimulate growth in low-informality economies, it can exacerbate corruption and inefficiency in high-informality settings, ultimately hindering growth. This aligns with Tran (2024), who found that increased *milex* can expand the shadow economy in certain regions. Policymakers in developing and transition economies should strengthen institutional frameworks to mitigate *milex*'s negative impact on growth. Future research should explore nonlinearities, short-run effects, and whether these effects are stronger in the short –or long –run.

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Figure 1. Evolution (on average) of Informality in our sample, 1990 - 2022

Source: Authors' processing, based on data from ICRG 2022

Figure 2. Evolution (on average) of Milex in our sample, 1990 - 2022

Source: Authors' processing, based on data from SIPRI Military Expenditure Database, Apr. 2024

Table 1. Summary statistics

Variables	Definitions	Mean	St. Dev	Min	Max	Perc. 1%	Perc. 5%	Perc. 95%	Perc. 99%
GDP_{it}	Gross Domestic Product (growth rate)	1.8728	6.2372	-30.4000	13.3223	-28.0021	-9.1173	8.8294	12.8908
$Milex_{it}$	Military spending (growth rate)	2.5485	1.4346	0.8950	11.1481	0.9431	1.1035	4.6708	9.1756
$Govexp_{it}$	Government Consumption expenditure (natural log)	22.6770	1.5767	18.7544	25.6231	19.2792	20.0157	25.3449	25.5763
Inv_{it}	Gross capital formation (% of GDP)	22.5941	6.6951	-0.3187	36.9245	2.9821	9.7273	33.0931	35.7784
$Trade_{it}$	Trade openness (% of GDP)	74.8018	26.3314	27.9830	170.8183	30.4760	39.1351	138.6507	161.2856
Pop_{it}	Total population (natural log)	15.9358	1.0564	14.4998	18.2579	14.5001	14.5069	18.0789	18.2389
$Secenrol_{it}$	Ratio of total enrolment to the population that officially corresponds to that education level	88.8587	12.3286	49.8229	115.7672	51.5828	67.4602	110.1827	114.5956
Law_{it}	See Table A1 of the Appendix	3.2060	1.884945	-6.7900	6.0000	-4.1700	-0.3300	5.0000	5.6666
$Inconf_{it}$		9.4769	1.7437	0.8333	12.0000	2.8333	6.5833	11.9166	12.0000
$Bureau_{it}$		2.2930	0.7356	0.7500	3.5000	1.0000	1.0000	3.0000	3.5000
$Inflcp_{it}$		40.0709	162.0732	-1083.8210	1500	-1.7358	-0.1046	199.8589	1058.3740
$Monfree_{it}$		65.0151	32.4801	-80.4000	198.0000	-59.5000	0.0000	86.1000	172.8000
$Timebus_{it}$		19.0694	14.3583	4.0000	61.5000	4.0000	4.7500	56.0000	61.5000
$Poverty_{it}$		26.9794	20.7072	-90.0000	68.0000	-70.0000	10.0000	59.0000	67.0000
$Corrup_{it}$		2.8329	0.8068	1.0000	5.0000	1.0000	2.0000	4.2500	5.0000
$Internet_{it}$		33.4845	30.3034	-15.7000	89.0040	-10.1000	0.0000	81.4084	86.6013
$Prorig_{it}$		45.6003	15.4999	20.0000	90.0000	20.0000	30.0000	70.0000	81.0000
$Govstab_{it}$		7.3153	1.6205	1.2500	11.0000	3.4166	4.8333	11.5000	19.1666

Notes: St. Dev and Perc. denote the variables' standard deviations and the corresponding percentiles respectively.

Table 2. Test for weak cross-sectional dependence

Variables	CD	CDw	CD*
$GDPgrowth_{it}$	15.97***	-2.15**	1.49
$Milex_{it}$	18.21***	-3.45***	-2.05
$Investment_{it}$	6.14***	-1.17	-1.18
$Trade_{it}$	23.56***	-2.14**	1.03
$SEnrollment_{it}$	13.17***	1.93*	4.33***
$Population_{it}$	-2.28**	-1.99**	-1.14
$Govexp_{it}$	31.19***	-0.24	-1.10
$Informality_{it}$	8.08***	3.29***	1.10

Notes: CD: Pesaran (2015, 2021), CDw: Juodis and Reese (2021), CD*: Pesaran and Xie (2021)
Null hypothesis: errors are weakly cross-sectional dependent; *,**,***, denote significance at 10%, 5% and 1% levels, respectively.

Table 3. Panel Unit Root Test Results

Variables	Im-Pesaran-Shin (2003)		Maddala – Wu (1999)		CIPS test (Pesaran, 2007)	
	Levels					
	Constant [W-t- bar statistic]	Constant & Trend [W-t- bar statistic]	Constant [Chi-squared statistic]	Constant & Trend [Chi-squared statistic]	Constant [Z-t- bar statistic]	Constant & Trend [Z-t- bar statistic]
$GDPgrowth_{it}$	-2.4763*** (0.0066)	-1.3132* (0.0946)	33.7901** (0.0134)	25.0810 (0.1227)	-2.4180** (0.0210)	-2.6940 (0.1140)
$Milex_{it}$	-2.7685*** (0.0028)	-1.2633 (0.1032)	56.9879*** (0.0000)	30.2913** (0.0347)	-2.5390*** (0.0080)	-2.5010 (0.2920)
$Investment_{it}$	-0.6801 (0.2482)	-0.2938 (0.3845)	19.9697 (0.3345)	14.5179 (0.6948)	-2.1250 (0.1360)	-2.2910 (0.5660)
$Trade_{it}$	5.5005 (1.0000)	-0.7428 (0.2288)	2.4055 (1.0000)	26.4828* (0.0892)	-1.6370 (0.6760)	-1.5560 (0.9960)
$SEnrollment_{it}$	0.0195 (0.5078)	3.0026 (0.9987)	14.2458 (0.7129)	6.5773 (0.9932)	-2.1030 (0.152)	-2.4330 (0.3760)
$Population_{it}$	4.9496 (1.0000)	1.9928 (0.9769)	6.0392 (0.9960)	12.7826 (0.8043)	-1.3840 (0.8970)	-1.6600 (0.9900)
$Govexp_{it}$	0.6320 (0.7363)	1.4236 (0.9227)	10.5436 (0.9127)	8.4989 (0.9702)	-0.5600 (0.2880)	-0.0280 (0.4890)
$Informality_{it}$	-0.2480 (0.4021)	-0.0152 (0.4940)	23.6071* (0.0984)	16.8007 (0.3986)	-1.9940 (0.2600)	-2.4840 (0.3220)
	First Differences					
$\Delta GDPgrowth_{it}$	-6.9048*** (0.0000)	-4.6292*** (0.0000)	107.2389*** (0.0000)	66.6790*** (0.0000)	-3.3600*** (0.0000)	-3.4260*** (0.0000)
$\Delta Milex_{it}$	-3.6141*** (0.0000)	-4.6015*** (0.0000)	61.6228*** (0.0000)	53.1366*** (0.0000)	-3.2700*** (0.0000)	-3.0990*** (0.0000)
$\Delta Investment_{it}$	-5.1936*** (0.0000)	-3.2753*** (0.0005)	67.6965*** (0.0000)	42.7121*** (0.0009)	-2.9170*** (0.0025)	-2.8680*** (0.0000)
$\Delta Trade_{it}$	-6.5542*** (0.0000)	-5.7704*** (0.0000)	90.4470*** (0.0000)	75.1290*** (0.0000)	-2.3400** (0.0370)	-2.6190 (0.1710)
$\Delta SEnrollment_{it}$	-2.8611*** (0.0021)	-1.0246 (0.1528)	43.7415*** (0.0006)	26.2954* (0.0932)	-4.1350*** (0.0000)	-4.1940*** (0.0000)
$\Delta Population_{it}$	-1.7200** (0.0427)	-1.2882* (0.0988)	32.6438** (0.0184)	27.6754* (0.0672)	-2.5400*** (0.0080)	-2.9950** (0.0130)
$\Delta Govexp_{it}$	-5.6235*** (0.0000)	-4.0403*** (0.0000)	76.7953*** (0.0000)	53.2232*** (0.0000)	-3.1010*** (0.0000)	-2.6230*** (0.0040)
$\Delta Informality_{it}$	-5.2414*** (0.0000)	-4.7571*** (0.0000)	53.9692*** (0.0000)	71.8107*** (0.0000)	-2.3740** (0.0370)	-2.5380 (0.262)
Notes: p-values in parentheses. *,**,*** denote significance at 10%, %5 and 1% respectively.						

Table 4. Panel Cointegration Tests and Long-Run Estimates

	Statistic values	**p-values**		
Perdroni's Tests				
Modified Phillips – Perron t	0.5606	0.2875		
Phillips – Perron t	-9.3278	0.0000		
Augmented Dickey – Fuller t	-8.6664	0.0000		
Kao's Tests				
Modified Dickey – Fuller t	-8.9135	0.0000		
Dickey – Fuller t	-11.7019	0.0000		
Augmented Dickey – Fuller t	-6.3011	0.0000		
Unadjusted Modified Dickey – Fuller t	-20.9127	0.0000		
Unadjusted Dickey – Fuller t	-14.3459	0.0000		
Westerlund Test				
Variance-Ratio	-2.0700	0.0192		
Cointegration Regression	***FMOLS***		***DOLS***	
$Milex_{it}$	-0.6223*** (0.0442)	-0.2590*** (0.0450)	-0.0890 (0.2885)	-0.7760*** (0.2410)
$Investment_{it}$	0.2282*** (0.0360)	0.2519*** (0.0365)	0.0820* (0.0447)	0.1082*** (0.0213)
$Trade_{it}$	0.0159 (0.0359)	0.0028 (0.0387)	0.0563*** (0.0120)	0.0111 (0.0084)
$SEnrollment_{it}$	-0.0456** (0.0206)	-0.0852*** (0.0238)	-0.0861*** (0.0255)	0.0049 (0.0250)
$Population_{it}$	-2.7665*** (0.0035)	-2.8722*** (0.0045)	-3.0348 (4.1604)	-1.0436*** (0.3009)
$Govexp_{it}$	2.0093*** (0.0202)	2.0212*** (0.0203)	0.4631 (0.4612)	0.6814* (0.3697)
$Informality_{it}$	0.7932*** (0.0147)	1.7603*** (0.0148)	1.0311*** (0.1355)	0.9474*** (0.3403)
$Informality_{it} * Milex_{it}$	-	-0.3836*** (0.0211)	-	-0.5208*** (0.1592)
Adj. R-squared	0.1982	0.2146	0.6011	0.5826

Notes: Standard errors in parentheses.
*,**,*** denote significance at 10%, %5 and 1% respectively.

Table 5. Granger non-causality test results

	DH			JKS
Direction of Causality	W-bar statistic	Z-bar	Z-bar tilde	HPJ Wald statistic
$Informality_{it} \rightarrow GDPgrowth_{it}$	1.0133	-1.4801	-1.4690	3.9786
$Informality_{it} \leftarrow GDPgrowth_{it}$	3.8215	2.7323	2.1078	5.4587
$Milex_{it} \rightarrow GDPgrowth_{it}$	1.0140	-1.4789	-1.4680	8.1232*
$Milex_{it} \leftarrow GDPgrowth_{it}$	2.5434	0.8151	0.4799	4.2012
$Investment_{it} \rightarrow GDPgrowth_{it}$	3.7581*	2.6372*	2.0270*	9.8945**
$Investment_{it} \leftarrow GDPgrowth_{it}$	3.4335	2.1503	1.6135	6.4161
$Trade_{it} \rightarrow GDPgrowth_{it}$	1.1636	-1.2547	-1.2776	9.0575*
$Trade_{it} \leftarrow GDPgrowth_{it}$	3.8954*	2.8431*	2.2018*	12.9531**
$SEnrollment_{it} \rightarrow GDPgrowth_{it}$	2.2335	0.3503	0.0852	0.9499
$SEnrollment_{it} \leftarrow GDPgrowth_{it}$	8.5100***	9.7649***	8.0792***	11.4828**
$Population_{it} \rightarrow GDPgrowth_{it}$	1.1962	-1.2058	-1.2361	18.6944***
$Population_{it} \leftarrow GDPgrowth_{it}$	9.2979	10.9468	9.0827	0.1776
$Govexp_{it} \rightarrow GDPgrowth_{it}$	4.0197	3.0295	2.3601	5.9449
$Govexp_{it} \leftarrow GDPgrowth_{it}$	2.9280	1.3920	0.9696	7.9790***
$Milex_{it} \rightarrow Informality_{it}$	4.3683*	3.5525*	2.8042*	11.6770**
$Milex_{it} \leftarrow Informality_{it}$	3.2533	1.8799	1.3840	0.6707

Notes: p-values computed using 100 bootstrap replications to account for the presence of cross-sectional dependence in the data. HPJ refers to the Half-Panel Jackknife Wald-type test for Granger non-causality. The Wald statistic is based on 100 bootstrap replicates to allow for cross-sectional dependence. The maximum number of lags was set to 4.
*,**,***, denote significance at 10%, 5% and 1% levels, respectively.

Appendix

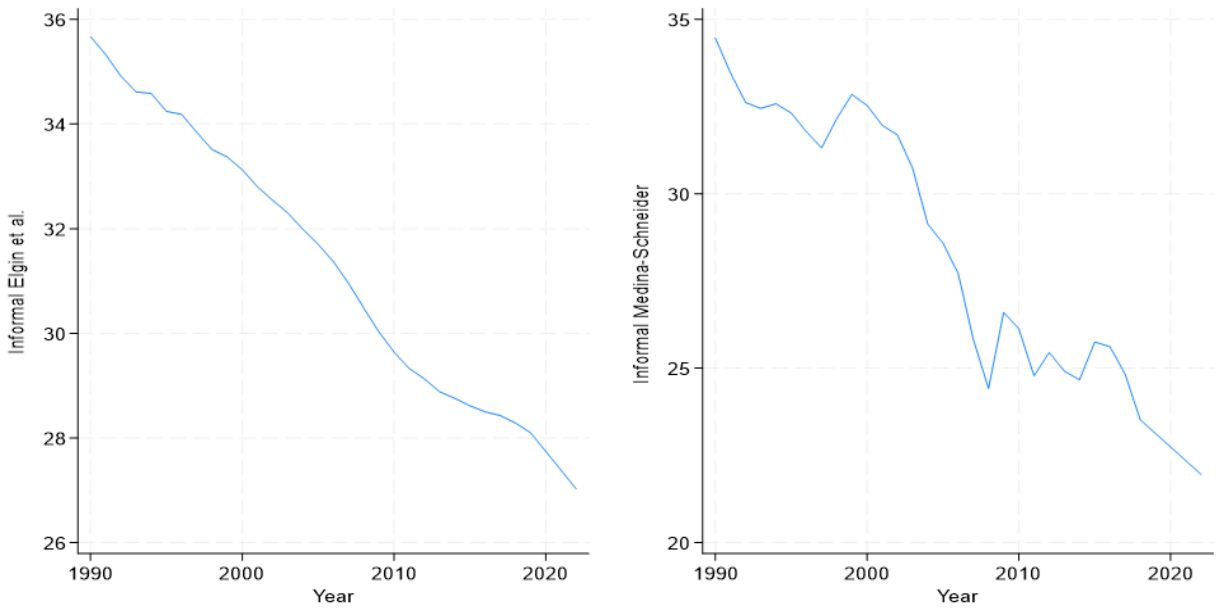
Definitions of Variables and Sources used for the Informality[7] index

Code	Variable name	Definition	Source
LAW	Law and order (index 0–3)	It is scored as a single component with two parts. The risk rating assigned is six points with a minimum of zero. The "Law" element assesses the legal system's strength and impartiality, while the "Order" element assesses public observance of the law. A nation's court system may be rated three stars, yet its crime rate may be ranked one star if the law is habitually disregarded without effective enforcement (For instance, massive unlawful strike activity).	The International Country Risk Guide (ICRG)
INCONF	Internal Conflict (index 0–4)	It assesses the level of political turmoil in the nation and its influence on governance. Most highly rated countries have no armed or civil opposition and no arbitrary violence, direct or indirect, against their own people. A country in a civil war gets the lowest rating. There are three components that make up the risk rating, each with a maximum of four points and a minimum of zero. 4 points = Very Low Risk, 0 points = Very High Risk. Terrorism/Political Violence; Civil Disorder.	The International Country Risk Guide (ICRG
BUREAU	Bureaucracy Quality	The quality of the bureaucracy acts as a shock absorber, in which it is reducing policy revisions when governments change. Thus, countries with strong bureaucracies that can govern without major policy changes or service interruptions receive high marks. In low-risk countries, the bureaucracy is usually independent of political pressure and has a well-established recruitment and training system. Changes in government are traumatic for policy formulation and day-to-day administrative functions in countries lacking a strong bureaucracy.	The International Country Risk Guide (ICRG)
INFLCP	Inflation, Consumer Prices (annual %)	It quantifies the proportional change in the cost of a set basket of goods and services to the typical consumer over a certain period of time.	World Bank Development Indicators (WDI)
MONFREE	Monetary Freedom (index 0–100)	It integrates a price stability metric with an evaluation of price regulations. Market activity is distorted by both inflation and price regulations. Without microeconomic interference, price stability is the optimum situation for the free economy.	Euromonitor International

[7] Numerous studies have reached consensus regarding the determinants of informal economy as being economic, political and institutional factors (La Porta and Shleifer, 2014; Medina and Schneider, 2018; Chen et al., 2020).

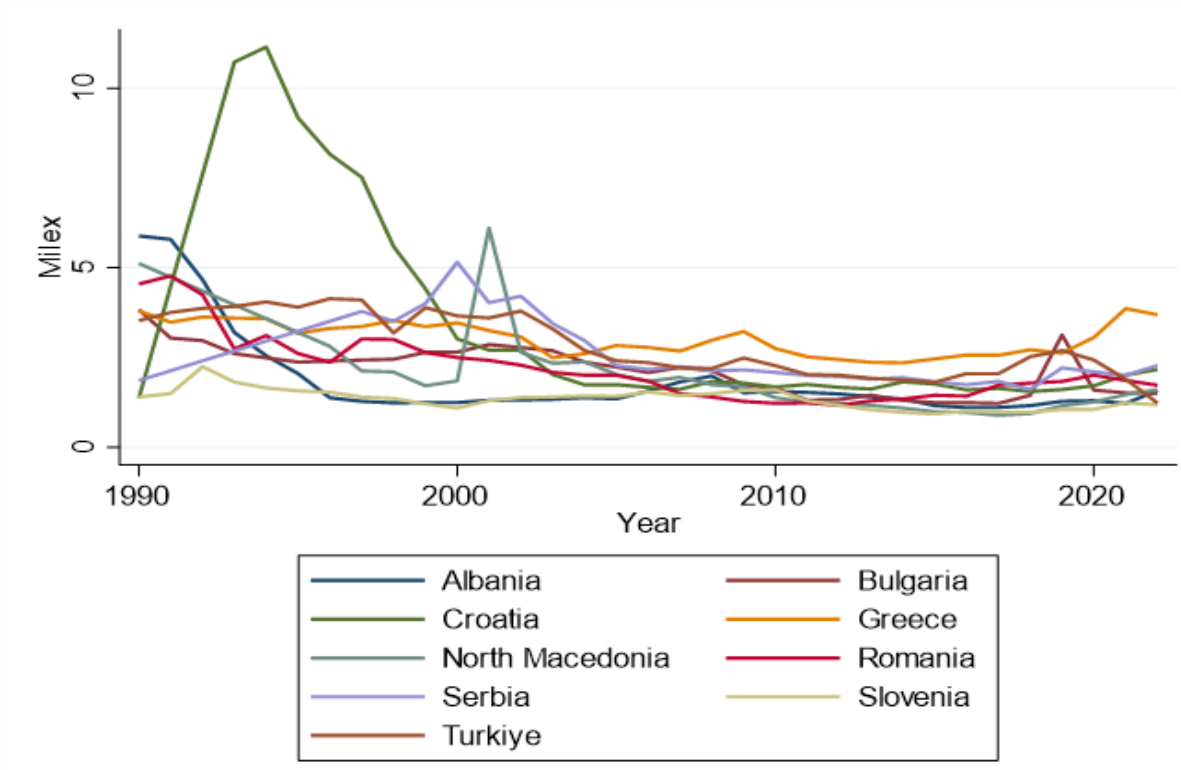
TIMEBUS	Time Required to Start a Business (days)	It refers to the time in days required to complete all the formalities for starting a firm lawfully.	World Bank Development Indicators (WDI)
POVERTY	Population Living Below National Poverty Line (% Population)	It is the percentage of people who live below the country's poverty threshold. Nationwide calculations are based on sample survey subpopulations estimates. Each nation has its own definition of poverty.	Heritage Foundation
CORRUP	Corruption (index 0–6)	This is a political corruption evaluation. Corruption is a danger to foreign capital for numerous reasons: it disrupts the financial and economic atmosphere; it decreases corporate and government efficiency by enabling individuals to obtain power by favour rather than talent; and it adds inherent political turmoil. The risk rating assigned is six points with a minimum of zero. 6 points = Very Low Risk, 0 points = Very High Risk.	The International Country Risk Guide (ICRG)
INTERNET	Individuals Using the Internet (% of the Population)	Individuals who have used the internet in the previous three months are considered internet users. The Internet may be accessed via a variety of devices, including computers, mobile phones, PDAs, gaming consoles, and digital televisions.	World Bank Development Indicators (WDI)
PRORIG	Property Rights (index 0–100)	The property rights component assesses individuals' ability to accumulate private property. It assesses how well a country's laws protect private property rights and how well its government enforces them. Additionally, it considers the risk of seizure, the independence of the court, and the capacity of people and enterprises to implement. The score is calculated on a scale of 0 to 100, with higher values indicating stronger protection of property rights.	The International Country Risk Guide (ICRG)
GOVSTAB	Government Stability (index 0–4)	It assesses the government's capacity to deliver and maintain power. Each sub-component of the risk assessment is assigned a maximum of four points and a minimum of zero.4 points = Very Low Risk, 0 points = Very High Risk. There is unity in government, legislative strength, and popular support.	The International Country Risk Guide (ICRG)

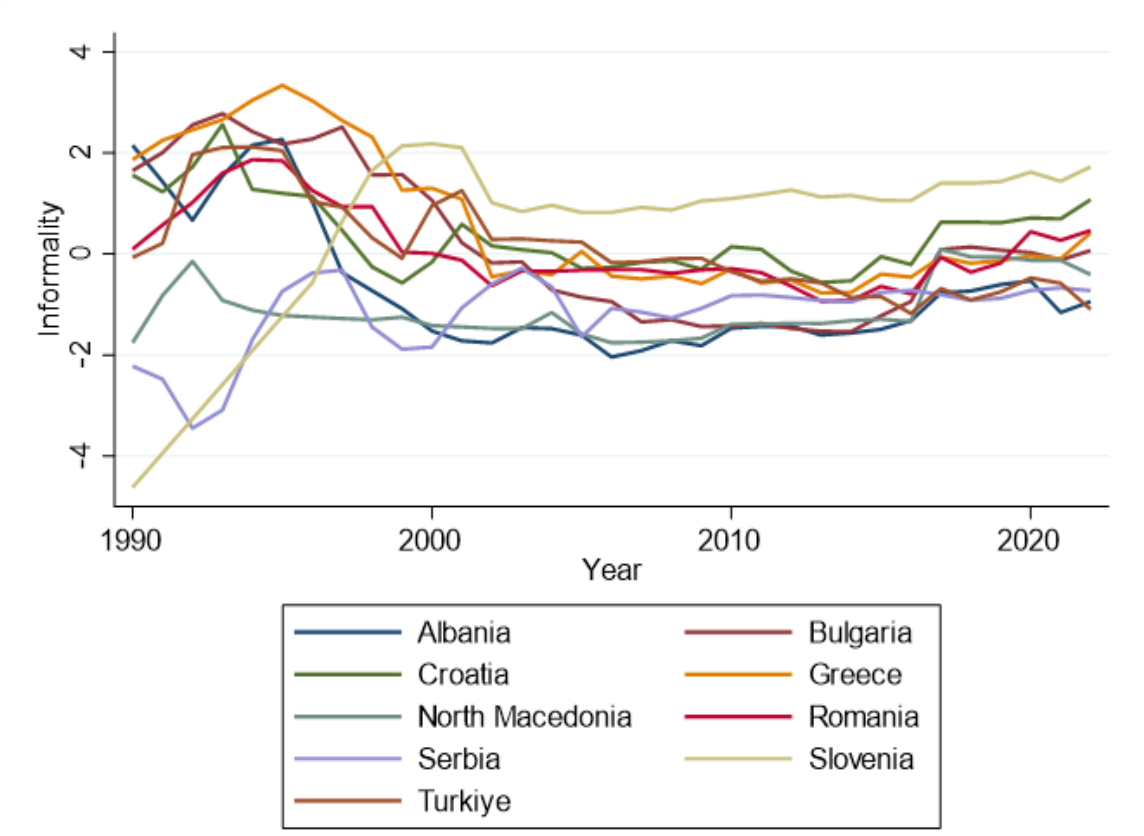
Figure i. Evolution (on average) of Informality in our sample 1990 - 2022

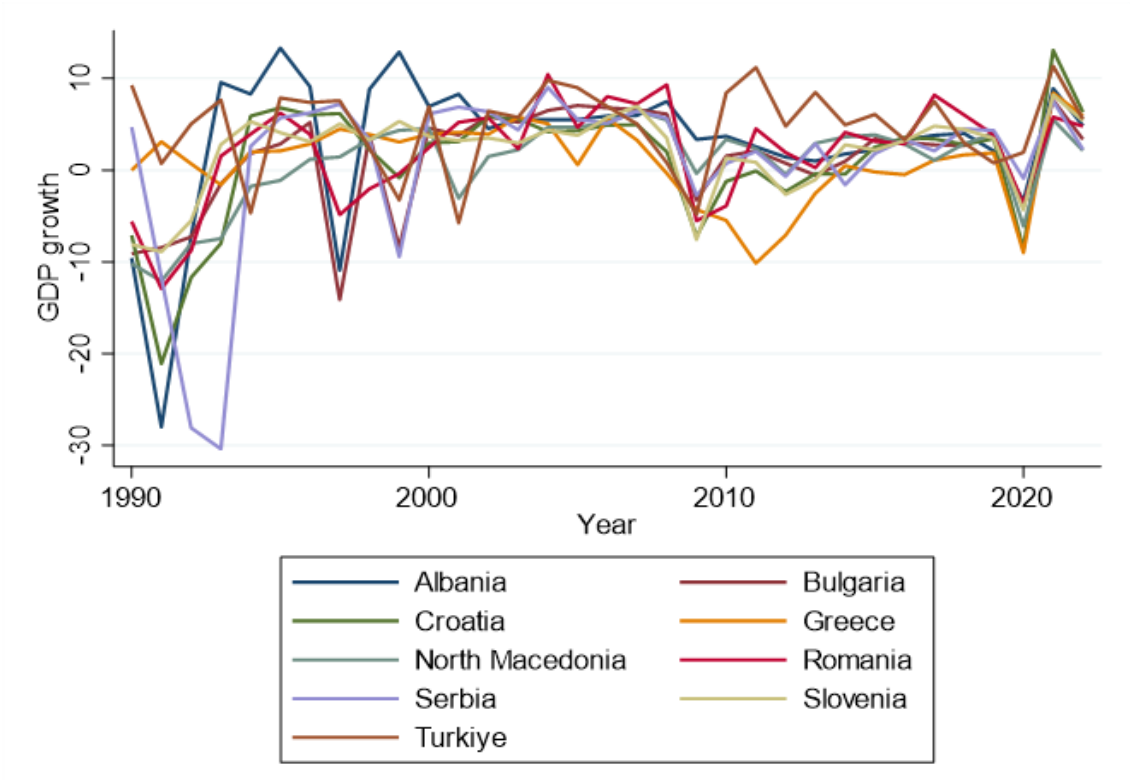


Source: Authors' own calculations [based on data form Elgin and Oztunali (2012) -updated by Elgin et al. (2021)- and Medina and Schneider (2019)]

Figure ii. Evolution of *Milex*, Informality, and GDP growth for the sample individual countries 1990 - 2022







Source: Authors' processing