An investigation on the natural rate of crime rates with Fourier panel unit root test in selected emerging economies

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Abstract

Purpose – The specific objective of the study is to investigate the presence of natural rate of crime rates in selected emerging economies by using panel unit roots. The majority of the literature examines the issue using conventional unit root tests in a country-specific context. Meanwhile, there is no panel unit root investigation has been undertaken considering both cross-sectional dependence (CD) and structural changes.

Design/methodology/approach – As a result, this study is to fill the aforementioned gap and validate the natural rate of crime rates for 10 countries by using a Fourier panel unit root test. The advantage of the test is that structural shifts are modelled as gradual or smooth changes with a Fourier approximation, and it also accounts cross-sectional dependency. Thus, the Fourier panel unit root test may have better performance in capturing potential changes in the nature of data.

Findings – The result of the conventional unit roots test shows evidence of the hysteresis effect in crime, as it stands does not adequately account for smooth transitions or breaks. On contrary, the Fourier panel unit root test confirms the natural rate hypothesis in crime rates. The present results highlight the detrimental effects of crime cannot be abated by short-run deterrence policies.

Originality/value – Contrary to previous studies, the theoretical implications of the study imply that the empirical models consider the dynamic nature of crime rates should account for natural rate properties instead of the hysteresis assumption.

Keywords Crime rates, Crime hysteresis, Panel Fourier unit root test, Emerging economies

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List of abbreviations/nomenclature

CADF	Cross-Sectionally Augmented Dickey-Fuller	FKPSS	Fourier Kwiatkowski-Phillips-Schmidt-Shin
CD	Cross-sectional Dependence	KPSS	Kwiatkowski-Phillips-Schmidt-Shin
		LM	Lagrange Multiplier

1. Introduction

Security, being one of the primary concerns affecting an individual's quality of life, is a fundamental component of a developed society. Accordingly, policymakers are expected to keep crime rates low by taking deterrent policy measures to ensure the safety of households. Since crime not only harms the victim but also produces negative economic consequences, economists have examined many of the negative externalities created by crime. Foreign direct investment, which is essential for long-term economic growth, is excluded from the market as crime rates rise (Brown and Hibbert, 2017; Cabral *et al.*, 2019). Criminal activity has a detrimental impact on the number of tourists and tourism revenues (Ahad *et al.*, 2022; Fourie *et al.*, 2020; Ulucak and Yücel, 2021). Also, the growing security concerns have negative consequences in the real estate market (Ceccato and Wilhelmsson, 2020; de Graaff, 2021). Taken together, the negative economic effects of criminal activity have directed scholars' attention to the causes and characteristics of crime rates.

It was not until the late 1960s that economists considered a crime worthy of scholarly attention (Becker, 1968). The first substantial theoretical studies dealing with crime modeled the issue as a matter of utility maximization (Becker, 1968; Ehrlich, 1973). A wide range of literature in different fields has arisen from the outset of this perspective and investigated potential socioeconomic determinants to reduce the motives of the crime. The studies were conducted on the long-term relationship between crime rates and crime deterrent policies, income inequality, demographic factors, labor market, industrial growth and schooling—which consist of controversial results (Hazra and Aranzazu, 2022; Noghanibehambari and Tavassoli, 2022; Raskolnikov, 2020; Lojanica and Obradović, 2020; Ajide, 2019, 2021; Bell *et al.*, 2016; Chalfin and McCrary, 2017; Furqan and Mahmood, 2020; Gillani *et al.*, 2009; Guza *et al.*, 2019; Torruam and Abur, 2014). Also, some studies emphasized the importance of artificial intelligence towards crime prevention (Douglas and Welsh, 2022; Hayward and Maas, 2021; Dospinescu and Lîsîi, 2016). One of the key reasons for these perplexing outcomes might be the apriori assumptions regarding the nature of crime rates in the case of the modeling procedure (Mocan and Bali, 2010; Ohlan, 2020).

In their seminal paper, Buck *et al.* (1983) and Buck *et al.* (1985) propose that a series of crimes have a natural rate of behavior. Therefore, increasing deterrence policies only create a temporary impact on crime rates. The probable explanation is that individuals who are far from long-term legal income generation experience do not choose to earn a legal income again. Also, the long duration of unemployment deteriorates legal human capital. Therefore, criminals prefer to stay away from legal earnings due to the accumulation of illegal human capital, no matter how much deterrence increases (Mocan and Bali, 2010). Besides, increasing the existing deterrent policies will not affect people who have committed crimes before. That's why criminals will continue their illegal behavior in a vicious cycle. Supporting this view, recent data from several countries show that detainees who were released were sentenced again within a few years (Yukhnenko *et al.*, 2019). Contrary to the natural rate of crime hypothesis, there are some views that crime rates are persistent responses to deterrent policy changes. In econometrical terms, the natural rate hypothesis is valid if the crime rates are stationary as a consequence of the unit root tests. Otherwise, the evidence shows that the hysteresis effect on the crime rate is validated. However, structural changes such as economic

crises and political regime changes in crime rate series may lead to structural breaks as a result of shocks (Cook and Cook, 2011; Narayan *et al.*, 2010). Analyzes that do not take into account the structural breaks may cause the estimated test statistics and coefficients to deviate. As a result, the hysteresis effect can be found to be true instead of the natural rate hypothesis. Therefore, unit root tests, which take structural breaks into account, were also should be used. This allows us to make reasonable inferences about whether the natural rate hypothesis of the crime rates of structural breaks is valid.

Turning now to the empirical literature on the natural rate of crime, it commenced with the investigation of the deterrence hypothesis for the regional data (Buck *et al.*, 1983). The study shows that increasing law enforcement is a deterrent in the short term, but crime rates return to their past rates neglecting the increasing costs of conducting crime. Buck *et al.* (1985) built the theoretical foundation of the natural rate hypothesis in their seminal paper. They suggest that the fundamental changes in crime rates only can be with policy structural changes in society. Using 10 years of data from 47 states of the United States, Friedman *et al.* (1989) find that criminals adapt to increase deterrence. Greenberg (2001) found hysteresis effect on crime rates in the United States. Greenberg (2001) emphasizes most of the previous works suffer from methodological shortcomings by disregarding unit roots on time series of crime rates and other criminology-related variables. He strongly suggests novel econometric methodologies should adapt to the existing criminology literature (Greenberg, 2001). Moreover, the presence of unit roots was validated by conventional unit root tests for the violent crime rates in the United States for a 40-year datum (Saridakis, 2004). Applying the unit root test with a structural break of Perron and Vogelsang (1992), McDowall and Loftin (2005) find evidence of hysteresis in crime rates. Cook and Cook (2011) carried out the first study using the unit roots with single and multiple structural breaks. The result of the study indicated that the series of crime rates present natural rate behavior for the United States. As a result of the conducted tests with multiple structural breaks, robbery and aggravated assault rate be stationary 1% significance level whereas motor vehicle theft, murder, rape and burglary confirm stationarity of the series at a 5% significance level. To better understand the properties of the crime rate series Narayan *et al.* (2010) set out a study to investigate the natural rate of the crime rate for G7 countries. In their seminal study, they applied for the first-time panel LM tests proposed by Im *et al.* (2005) which allows researchers to specify structural breaks. Narayan *et al.* (2010) reject the hysteresis effect on crime rates in the subject countries. Loureiro (2013) contributed to the criminology literature with an econometric framework that can be applied which accounts for the hysteresis effect in crime rates. On the other hand, Cortez (2017) provide evidence against the natural rate hypothesis for a region in Mexico. Sahu and Mohanty (2016) found evidence against hysteresis in crime rates under the specification of unit root tests with structural breaks for India. Contrary to this, Ohlan (2020) provide more inferences by checking natural rate hypothesis for India in regional level analysis. This study also supports the view of natural rate of crime rates for India.

It is widely recognized that structural issues such as unemployment, poverty, inequality, a lack of social security and education level play a significant role to determine crime in the long run. Thus, law enforcement expenditure alone cannot lower crime beyond a certain level which is known as the natural rate. The presence of a natural rate can be a possible explanation for why deterrent measures fail to reduce the crime rate in the long run (Buck *et al.*, 1985). The existence of a natural rate of crime implies that the deterrent measures only have short-term impacts and that, over time, the crime rate returns to its previous level in the long run. Given the significant social costs associated with criminal activity, it is crucial to comprehend the dynamics of the crime rate to develop effective policies. To this end, the hysteresis hypothesis can be tested by using unit root tests on the crime rates. A non-stationary crime rate series shows that shocks to the series have a permanent effect which affirms that the crime rate does not converge to a natural rate (i.e. the equilibrium level) over time. On the other hand, a stationary time series of the crime rate provides that shocks to the series are temporary and that, over time, the series returns to its equilibrium

level. Previous studies on this subject area have focused on developed nations and very few studies have investigated time series properties of crime rate. Therefore, this study contributes to the literature by examining whether there is a natural rate of crime, using the prison inceration rate of selected 10 emerging economies between the period 2003 and 2017.

This study differs from previous studies in several respects. Firstly, to the best of our knowledge, this is the first comprehensive cross-country investigation on the hypothesis of hysteresis in crime rates. This study presents a global investigation including selected 10 emerging economies. Moreover, the unit root tests conducted in this paper both accounted for the cross-sectional dependence and structural changes. Especially, this study applies the Fourier panel unit root tests which enable practitioners to check for structural changes gradually or suddenly (Nazlioglu and Karul, 2017). Therefore, this study can provide a more robust inference on whether there is a hysteresis effect on crime rates or not. As we stated in earlier sections previous studies neglected to have cross-country inference. The only panel investigation implemented by Narayan *et al.* (2010) for 7 countries—is only applied conventional unit root techniques. Secondly, the presence of natural rate or hysteresis in crime rates would contribute to building processes for theoretical models. Specifically, the presence of the natural rate hypothesis could create the necessity for a revisitation of many cointegration studies in the literature. Third, this study uses the prisoner rate per 100.000 people as a proxy to have overall inference. Contrary to focusing on some categories of crime— e.g, rape, homicide, motor vehicle theft, etc.— prisoner rate allows us to deduct holistic inferences for the crime rates which is well documented in the literature (Jones *et al.*, 2017; Rodríguez-Menés and López-Riba, 2020; Wiig, 2018; Yukhnenko *et al.*, 2019).

The remainder of the paper is organized as follows. Section 2 introduces the data and methodology used in the current study; section 3 discusses empirical results. Finally, section 5 provides the conclusion.

2. Data and methodology

This study uses annual data on prison incarceration rates per 100.000 individuals in 10 countries including the years 2003–2017. The reason for this is that the subjected variable is a good proxy of crime rates and therefore lets us have good estimates rather than a single type of crime rate investigation. The data was compiled from United Nations Drug and Organizational Crime Datasets. Table 1 shows the list of the subject countries. The motivation for the selected economies stems from the fact that these economies are emerging and fragile in their economic trajectory. Thus, the investigation of this sort of crime is a pertinent element of perpetual economic and sustainable growth. For instance, Turkey, Brazil and the rest are well-rooted as E7 members with a very promising economic mix. Further motivation of the country stems from the fact according to the global crime index ranks the selected countries with high crime rate and similar crime indices [1]. Figure 1 depicts the trend of crime rate of the observed economies over the study period. However, the selected countries have very high economic prospects but its crime rate can impede the economic trajectory. It is also observed the mentioned countries have weak institutional apparatus that has weaken the rule of law, accountability and good governance. Additionally, the use of the Fourier econometric tool contributes to the extant literature to present able estimates for adequate policy formulation and crafting for the economies under review. The economies are emerging

Table 1.
The list of subjected countries

(1) Brazil	(6) Greece
(2) Bulgaria	(7) Hungary
(3) Chile	(8) Peru
(4) Colombia	(9) Poland
(5) Czech Republic	(10) Turkey

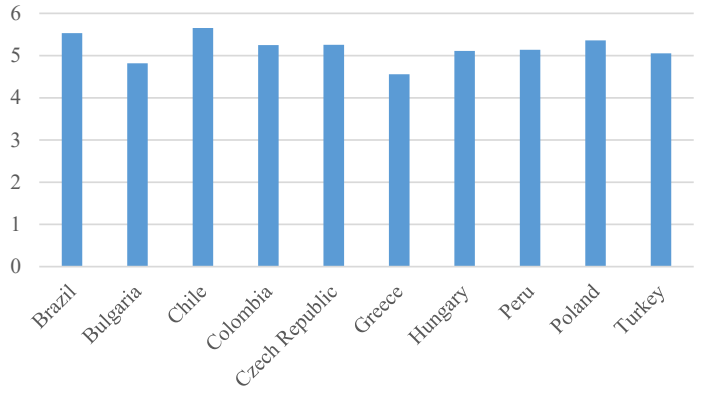

Figure 1.
The visual demonstration of crime rates for each cross-section (%)

and fragile and crime plays a pivotal role in their economic trajectory and attraction of foreign investment. In the following sections, the term crime rates will be used to refer to the prisoner population rate per 100.000 individuals.

3. Panel Fourier stationarity test

In time series analysis, stationarity implies that the mean and variance of the variables are not changing in course of time. Then, the stationary series has to mean-reverting process since shocks do not have any permanent impact on the series over time. Policy implications cannot be efficient for any stationary series due to the transitory effect of shocks on the series. Thus, the policy effectiveness depends on the nature of the series. So, it is crucial to apply a proper unit root test to investigate the stationarity properties of the series. With this aim, there are new generation panel unit root tests have been introduced to the econometric literature such as Cross-Sectionally Augmented Dickey-Fuller (CADF) unit root test. The main feature of these new-generation unit root tests is to account for possible cross-sectional dependency in cross-sections. However, considering only cross-sectional dependency is not enough to choose the proper unit root test to avoid biased inferences. Perron (1989) states that the null hypothesis cannot be rejected under the presence of structural break(s) in the series. Then, it may lead false hypothesis decision for the series. It is also important to take into account structural breaks in the unit root test procedure.

The reliability of the structural break unit root tests depends on the information about structural breaks such as the number and forms of break dates. To deal with these circumstances, the Fourier Panel KPSS unit root test is proposed by Nazlioglu and Karul (2017). This novel test combines the time series stationarity test for structural breaks modeling with a Fourier approximation which is proposed by Becker *et al.* (2006) and the panel stationarity test under cross-sectional dependence (Hadri and Kurozumi, 2011, 2012). The advantage of the test is no need to determine the break form and date beforehand during the modeling phase of the test. Also, the Fourier Panel KPSS tests allow not only sharp breaks but also smooth transitions or gradual breaks. The first stage is to consider the following data-generating process as below:

$$y_{it} = z_i(t) + r_{it} + \delta_i F_t + \varepsilon_{it} \tag{1}$$

$$r_{it} = r_{it-1} + u_{it} \tag{2}$$

where $i = 1, \ldots, N$ and $t = 1, \ldots, T$. r_{it} is a random walk process, ε_{it} and u_{it} are error terms with identically distributed and correlatively independent across cross-sections (i) and over time (t). Unobserved common factors and loading weights are denoted by F_t and δ_i. Equation (1) defines the deterministic term as a time-dependent function indicated by $z_i(t)$. Thus, any structural shifts or asymmetry in the deterministic term can be captured through a Fourier approximation which mimics a variety of breaks regardless of the number, date and form of the shifts (Becker *et al.*, 2006). If the constant term includes any structural breaks without a certain form, the following Fourier expansion with a single-frequency component is calculated as:

$$z_i(t) = z_i + \varphi_{1i} sin\left(\frac{2\pi kt}{T}\right) + \varphi_{2i} cos\left(\frac{2\pi kt}{T}\right) \tag{3}$$

where φ_{1i} and φ_{2i} denote the amplitude and displacement of shifts, and k refers to Fourier frequency. Moreover, the nonlinear trend function is proposed by Jones and Enders (2014) which is also approximated with the following Fourier expansion:

$$z_i(t) = z_i + \gamma_i t + \varphi_{1i} sin\left(\frac{2\pi kt}{T}\right) + \varphi_{2i} cos\left(\frac{2\pi kt}{T}\right) \tag{4}$$

It is worthwhile noting that the Fourier Panel KPSS test the null hypothesis of stationarity against the alternative hypothesis of a unit root [2].

4. Empirical results

This section proceeds with the preliminary analysis that highlights basic summary statistics of the observed variable. To this end, the properties of the natural logarithm of crime rate is examined to show measures of central tendency and dispersion alongside its normality properties as presented in Table 2. According to Table 2a, Greece has the lowest average crime rate while Chile has the highest rate. The standard deviations of the variables show that the variable is dispersed around its means. The standard deviation of the crime rate is not volatile for the selected economies. The highest standard deviation is observed for Turkey

(a) Descriptive Statistics

	Obs	Mean	Std. Dev	Min	Max
Brazil	15	5.531	0.241	5.051	5.859
Bulgaria	15	4.819	0.128	4.591	5.003
Chile	15	5.653	0.147	5.444	5.869
Colombia	15	5.251	0.238	4.919	5.535
Czech Republic	15	5.257	0.099	5.057	5.390
Greece	15	4.559	0.126	4.349	4.719
Hungary	15	5.110	0.083	4.964	5.206
Peru	15	5.137	0.316	4.673	5.628
Poland	15	5.360	0.068	5.242	5.464
Turkey	15	5.055	0.402	4.412	5.775
Panel	150	5.173	0.368	4.349	5.869

(b) Normality test for the bloc

Lilliefors	Cramer-VonMises	Watson	Anderson-Darling	Jarque-Bera	Shapiro–Wilk
0.07**	0.10*	0.09*	0.71*	4.074	0.97**

Note(s): * is representative of significance at a 1% level, ** is representative of significance 5% significance level

Table 2. Descriptive statistics and normality test results for crime rate

over the study period. In summary, the average means revolved around similar values which depict the fact that selected countries share similarities in their crime indices over the study period as highlighted in Table 2a last column. Subsequently, the bottom of Table 2b shows normality test statistics of crime rates. The present study leverages on six methods after the study of (Anderson and Darling, 1954; Dallal and Wilkinson, 1986; Durbin, 1973; Jarque and Bera, 1980; Lewis, 1961; Shapiro and Wilk, 1965). The result of the Watsons and Jarque-Bera normality rejects the normality of the series. Contrary to this, findings reported by Cramer-VonMises, Shapiro–Wilk and Anderson-Darling tests emphasize that series normal. Figure 1 also visually demonstrates the crime series; it can be inferred that trend and constant specification of unit root tests improve the efficiency of results.

In panel data analysis, examining the presence of cross-sectional dependence (CD) is prominent of outlined interest variables to employ proper modeling. In this respect, the presence of CD is tested for crime rates. The results are provided in Table 3. According to Table 3, the null hypothesis of no CD in cross-sections is rejected at 1% significance level. Thus, this finding supports cross-sectional dependency for the bloc countries.

As a result of the conducted CD tests, there is no cross-sectional independence. Thus, the unit root tests that do not account for CD may lead to biased results. With this aim, we have applied conventional unit roots tests such as with demeaned averages for each cross-section, which diminishes the impact of biased results due to the presence of CD. Also, this study employs another unit root test under cross-sectional dependence which is the CADF method of Pesaran (2007), because conventional methods fundamentally do not take into account cross-sectional dependency. Therefore, the finding of these tests could be misleading. In Table 4, Hadri (2000) statistics show that the null hypothesis of stationary is rejected at 1% significance level. Similarly, Breitung (2001) and Pesaran (2007) unit root test results indicate that the null hypothesis of nonstationary cannot be rejected at the level form of the variable for both models. However, the variable becomes stationary after taking the first difference. The conventional unit root test results are in harmony that the crime rate has a unit root. Thus, we can conclude that the impact of shocks is permanent. This is consistent with the crime rate hysteresis hypothesis.

As we mentioned before, the traditional unit root tests do not take into account structural changes. Hence, the findings can be misleading. To avoid spurious inferences, we proceed further to investigate the possibility of failure to reject the unit root hypothesis due to the existence of structural breaks in the crime rate series. The merit of the Panel Fourier KPSS analysis enables us to circumvent the shortcomings of conventional unit root tests. To this end, the study utilized the FKPSS analysis to validate the existence of crime hysteresis in each country of ten selected emerging economies. Therefore, the results of the FKPSS analysis are robust for policy crafting. Table 5 presents the results of the FKPSS test. Against the results of conventional unit root tests,

Variable	Breusch-Pagan LM	Peseran CD	Bias-corrected scaled LM	Peseran LM
Crime rate	236.953*	−1.760**	2.686*	20.234*

Note(s): ** and * denote the significance level at 5 and 1%

Table 3. Cross-sectional dependence test results

Model	Hadri	Breitung	PESCADF	Hadri	Breitung	PESCADF
	Level			First difference		
Constant	22.198*	−0.740	−1.493	1.911	−2.952**	−2.288**
Constant and trend	10.890*	0.700	−2.602	1.538	−1.904**	−2.772***

Note(s): The Asterisks (***), (**) and (*) denote the statistical significance at 10%, 5% and 1% levels, respectively

Table 4. Conventional unit root test results

Countries	Constant[a] FKPSS $k = 1$	Constant[a] FKPSS $k = 2$	Constant[a] FKPSS $k = 3$	Constant and Trend[b] FKPSS $k = 1$	Constant and Trend[b] FKPSS $k = 2$	Constant and Trend[b] FKPSS $k = 3$
Brazil	*0.022*	*0.047*	*0.045*	*0.022*	*0.024*	*0.022*
Bulgaria	*0.017*	*0.041*	*0.037*	*0.017*	*0.023*	*0.020*
Chile	*0.021*	*0.074*	*0.076*	*0.018*	*0.021*	*0.020*
Colombia	*0.023*	*0.122*	*0.110*	*0.019*	*0.025*	*0.023*
Czech Republic	*0.027*	*0.095*	*0.060*	*0.024*	*0.030*	*0.025*
Greece	*0.017*	*0.020*	*0.022*	*0.017*	*0.020*	*0.022*
Hungary	*0.020*	*0.031*	*0.026*	*0.018*	*0.027*	*0.026*
Peru	*0.022*	*0.058*	*0.036*	*0.020*	*0.037*	*0.029*
Poland	*0.021*	*0.137*	*0.117*	*0.020*	*0.025*	*0.021*
Turkey	*0.060*	*0.295*	*0.333*	*0.026*	*0.020*	*0.025*
Panel statistics	*0.042*	*0.308*	*0.335*	*0.038*	*0.078*	*0.104*

Note(s): The italic numbers indicate the null hypothesis of stationarity cannot be rejected at least at the 10% significance level

[a] The critical values for individual statistics are 0.132 (10%), 0.172 (5%) and 0.270(1%) for $k = 1$, 0.315 (10%), 0.415 (5%) and 0.667 (1%) for $k = 2$ and 0.339 (10%), 0.448 (5%) and 0.718 (1%) for $k = 3$

[b] The critical values for individual statistics are 0.047 (10%), 0.055 (5%) and 0.072(1%) for $k = 1$, 0.103(10%), 0.132 (5%) and 0.202 (1%) for $k = 2$ and 0.114 (10%), 0.142 (5%) and 0.210 (1%) for $k = 3$

Source(s): All critical values are obtained from Becker *et al.* (2006)

Table 5.
The panel Fourier KPSS test results

the null hypothesis of unit root cannot be rejected for the bloc countries irrespective of the Fourier frequency. This shows that the crime rate is found to be stationary under consideration of possible structural break(s). Thus, the effect of shocks is temporary and the crime rate will return to its equilibrium in the long run. This is consistent with the presence of a natural rate of crime for each country of ten selected emerging economies. This finding is aligned with Narayan *et al.* (2010) who found strong evidence of the natural rate of crime for a panel of G7 countries. Also, Sahu and Mohanty (2016), Ohlan (2020) state that the natural rate of crime hypothesis is valid for China.

5. Conclusion

The current study aims to determine whether the phenomena of the natural rate of crime apply to growing economies. Our study differs from previous research in several respects. Firstly, previous studies relied heavily on nationwide data with applications of conventional unit root tests. To the best of our knowledge, this is the first study that applies the Fourier panel unit root test — which considers structural changes in a gradual manner (Nazlioglu and Karul, 2017). Secondly, using prison incarceration rates that are parallel to crime rates allows us to draw more accurate conclusions about criminal phenomena. This improves the ability to understand crime dynamics in a more deductive manner (Jones *et al.*, 2017; Rodríguez-Menés and López-Riba, 2020). Studies that focus on certain sorts of crimes, such as murder, fraud, or sexual violence, do not accurately capture the portrait of crime dynamics in society.

Turning now to the statistical outcome of traditional unit root tests, it can be seen that the hysteresis on crime rates is valid for emerging economies. The most likely explanation for this conclusion is that traditional approaches do not account for structural changes and overlook cross-sectional dependence. For this reason, researchers should use techniques that account for breakpoints in series, which would lead to reliable results (Ohlan, 2020). Because of this, techniques that progressively address structural changes might help practitioners avoid mistakes (Nazlioglu *et al.*, 2021; Ucler and Bulut, 2021). The Fourier panel unit root test is performed to take into account not only sharp breaks but also smooth transitions or gradual breaks. The test results show that the natural rate of crime is valid in selected emerging economies.

Contrary to previous studies, the theoretical implications of the study imply that the empirical models consider the dynamic nature of crime rates should account for natural rate properties instead of the hysteresis assumption (Cortez, 2017; Loureiro, 2013). In addition, it is confirmed once again that short-term interventions are unsuccessful with the acceptance of the natural rate hypothesis (Cook and Cook, 2011; Ohlan, 2020). In a practical sense, the findings suggest that deterrent policies suffer from creating the necessary impact on emerging economies. As a consequence, policymakers must investigate the fundamental triggers of crime in society and devise long-term strategies to combat the problem. New participants in the criminal market should be prevented from entering the criminal market, as criminals adapt to use alternative methods under all deterrence. In this regard, one of the most cost-effective policies that will change the human capital in the best way can be provided by the social change that will occur with education (Furqan and Mahmood, 2020; Karpowitz *et al.*, 1995; Kiknavelidze, 2021). Juveniles who do not receive the discipline of conscience in their families can only be reintegrated into society in this way. On the other hand, the legal earning availability should be improved for the crime-induced territories (Apel and Horney, 2017; Bianchi and Chen, 2022). Investors can be attracted by establishing high-security industrial zones in crime-ridden areas and providing necessary incentives. Property security provided to entrepreneurs will bring peace and more vacancy to society.

There are obvious limitations beyond the scope of this study. It might be possible to draw more complete conclusions on this topic in case different data sources with longer time dimensions were available. It will be beneficial for researchers if institutions act more sensitively in data collection and distribution. As Hazra and Aranzazu (2022) and Hayward and Maas (2021) proposed in their study, future studies can consider the pivotal role of institutional apparatus, artificial intelligence, human capital development via education and income equality on crime mitigation for other regions not considered in the present study.

Notes

1. For more information on crime indices for the selected countries see https://www.numbeo.com/crime/rankings_by_country.jsp?title=2020
2. Further details of Fourier panel KPSS unit root test by Nazlioglu and Karul (2017) are available in Nazlioglu, S., and Karul, C. (2017). A panel stationarity test with gradual structural shifts: Re-investigate the international commodity price shocks. Economic Modelling, 61, 181–192.

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