Convergence of Crime in Turkey: Time Series Analysis with Accounting Structural Breaks

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Abstract

This study examines the potential convergence in crime rates among 12 regions in Turkey for evaluating whether crime fighting socio-economic policies should be constructed at a national or regional level. Turkey's aggregated crime data indicate that total crime per 100000 inhabitants increased approximately by 190% during 1990-2016. Moreover, this topic is noteworthy for Turkey in the presence of variations of crime across regions and number of convicted prisoners due to remission of punishment or financial crisis. We employed different techniques to capture the role of structural shifts. The results of conventional unit root tests provide very few evidence for convergence. This contradicts starkly with two sharp shifts results. Finally, gradual shift testing does not show clear-cut evidence for divergence. However, β-convergence testing supports strong evidence in favor of divergence. These indicate that consideration of structural breaks are critical in terms of policy implications and regional socio-economic policies should be implemented.

Keywords: Crime, Convergence, Structural Break
Jel Classification: C32, K42, R10

Türkiye'de Suç Oranlarının Yakınsaması: Yapısal Kırılmaları Dikkate Alan Zaman Serisi Analizi

Öz

Bu çalışma, suçla mücadeleye dair sosyo-ekonomik politikaların ulusal mı yoksa bölgesel düzeyde mi oluşturulması gerektiğini belirlemek amacıyla Türkiye'deki 12 bölgede suç oranlarının yakınsamasını incelemektedir. Suç verileri, her 100000 kişi için toplam suçun 1990-2016 yılları arasında yaklaşık %190 oranında arttığını göstermektedir. Suç oranlarının bölgesel farklılıkları ve ceza affı ve finansal kriz yıllarında mahkûmların sayısında önemli değişiklikler yaşanması politika yapıcılar açısından konuyu önemli kılmaktadır. Çalışmada yapısal kırılmaları dikkate alan ve almayan yöntemler kullanılarak önceki çalışmalardan farklı olarak kırılmaların varlığının sonuçlar üzerindeki etkisi tartışılacaktır. Geleneksel birim kök testlerinin sonuçları suç oranlarının bölgeler arasında daha çok ıraksadığını göstermektedir. Bu sonuçlar, iki keskin kırılmaya izin veren birim kök testi sonuçlarıyla çelişmektedir. Fourier birim kök test sonuçları ise, suç oranlarının bölgeler arasında ıraksadığını göstermektedir. Dahası, β-yakınsama testi, bölgeler arası ıraksama lehine güçlü kanıtlar sunarken, suça yönelik bölgesel sosyo-ekonomik politikaların gerekliliğini ortaya çıkarmaktadır. Ayrıca sonuçlar, yapısal kırılmaların dikkate alınmasının ve modellenme biçiminin politika çıkarımı açısından önemini göstermektedir.

Anahtar Kelimeler: Suç, Yakınsama, Yapısal kırılma
JEL Sınıflaması: C32, K42, R10

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1. Introduction

From a sociological and criminological perspective, crime has been mostly related to the individual's mental states, culture, sociological structures, etc. However, primarily Becker (1968) and subsequently Ehrlich (1973) emphasize that the decision of committing a crime is based on a "cost-benefit analysis" of an individual which considers the expected return of crime. Since these seminal papers on the economics of crime, a vast empirical literature has examined several links between crime and socio-economic variables such as education, unemployment, economic growth, inequality, number of police, the young population, etc. These indicators appear to be related to the economic approach of crime due to impact channels which are named as *motivation* and *opportunity* effects (Eide, Rubin, and Shepherd, 2006). On the one hand, if the socio-economic conditions provide lower potential gain, individuals may be motivated to commit a crime. On the other hand, if the opportunity cost of crime is high, criminal tendencies may decrease.

Some of the research on this topic focused on the determinants of crime, and the emphasis has been more on unemployment and income inequality. Both economic and sociological theory with some plausible reasons suggests that unemployed and low-income individuals are more likely to be in criminal activity. Most of the empirical work verified these arguments and showed that unemployment and income inequality have a strong positive impact on crime for aggregated or some disaggregated crime categories (Cornwell and Trumbull, 1994; Kelly, 2000; İmrohoroğlu, Merlo, and Rupert, 2000, 2004; Fajnzylber, Lederman, and Leayza, 2002; Soares, 2004; Baltagi, 2006; Enamorado, Lopez-Calva, Rodriguez-Castelan, and Winkler, 2016), while some others suggest that these effects may be very small, insignificant or even negative (e.g. Neumayer, 2005; Choe, 2008; Altındag, 2012; Chintrakarn and Herzer, 2012).

On the other hand, some other studies focused on the growth impact of crime and suggested that crime may restrain long-run economic growth through particularly three channels: First, crime increases uncertainty, and the cost of doing business thereby discourage entrepreneurial activities and foreign investment. Second, it reduces the effectiveness of the economy by transferring public and private sector resources from productive activities to security expenses. Third, it lowers labor supply by reducing skilled worker through encouraging migration due to the fear of criminal activities and by keeping workers out of the labor market due to the rejection of jobs in off-hours and far from home (e.g. Mehlum, Moene, and Torvik 2005; Stone, 2006; Powell, Manish, and Malavika, 2010).

Empirical studies on this subject also showed contradictory results. For example, utilizing Italian regional data covering the period 1963-95, Mauro and Carmeci (2007) found that homicide rates have negative long-run income level effect but not long-run growth effect. But then, Detotto and Otranto (2010), using monthly data from 1979-2002 for the Italian

case, found a statistically significant negative effect of homicide crimes on growth. Using municipal data for Mexico over the period 2005-2010, Enamorado, Lopez-Calva, and Rodriguez-Castelan (2014) showed that although non-drug related crimes have no statistically significant effect on growth rates, drug-related crimes have a negative impact on income growth. A recent study of Goulas and Zervoyianni (2015) suggested that indefinite conclusion on the crime-growth relationship is stemmed from the existing literature uses reduced-form models and ignores the sensitivity of this relationship to changing economic conditions. Accordingly, they showed that although crime does not hamper growth when economic conditions are satisfactory, during the periods of worsening economic conditions, reducing crime rates affect growth positively. These various findings indicate that both the sources of criminal activity and the impact of crime on the economy may change with regard to the types of crime, place and time.

Furthermore, over the last decades, a group of studies has taken a completely different approach, without considering the potential relationship between crime and other socio-economic variables, examined explicitly whether there is a uniform national trend or regional differences in various types of crime. These studies argue that even if varieties in the level of crime rates, there may be a similar trend among regions. The motivation for these works is quite clear. If the weakness of the similarities between regions is confirmed, it implies that the role of local factors is more important than nationwide, and accordingly, crime-fighting policies should be at a regional level. Studies in this context can be divided into basically two groups. While the first group analyzed the existence of a national trend in crime rates with various approaches such as simple ranking and correlation techniques or regression methods (e.g., Winsberg, 1993; Messner, Deane, Anselin, and Pearson‐Nelson, 2005 and McDowall and Loftin, 2009), other group examined the existence of a "catching up effect" across regions (e.g. Cook and Winfield, 2012; Baharom, Habibullah, and Royfaizal, 2008). The second type of researches focus more on the potential emergence of a national trend and consider in some of the states; crime rates may persistently exhibit higher or lower values than others, however, in time, there may be a convergence or a divergence movement across regions. This approach is also quite instructive because if divergence is confirmed, determinants of crime should be analyzed in regional context and accordingly policymakers should implement regional crime-fighting policies rather than nationwide.[3]

[3] Besides, distinctive crime convergence studies exist regarding gender bias in recent years (Valdivia and Castro, 2013; Estrada, Backman, and Nilsson, 2015; Beatton, Kidd, and Machin, 2018; Campaniello and Gavrilova, 2018). These investigated the gender crime convergence among male and female. More specifically, they focused on the process and dynamics of the gender gap or convergence of different types of crime.

While this issue has great importance for developing countries with high crime rates, a significant number of studies have examined the US states and EU countries. In this respect, crime has become an important research subject for also Turkey due to the significant variations of crime across regions. Aggregated crime data of Turkey shows that the number of total convicts received into prison increased from 44.7 thousand in 1990 to 187.7 thousand in 2016. In this period, the lowest growth ratio of convicts received into prison was seen in 2005, and the highest growth ratio was seen in 2007. This change is sourced from the arrangements of the related laws (TUİK, 2016).[4] Although given this overall trend for total crime, some of the sub-regions of Turkey persistently exhibit relatively higher (e.g., West Marmara and Aegean) or lower values (e.g., Centraleast Anatolia) than others. In other words, the databased observation shows crime disparities among the regions. As mentioned earlier, regional differences in crime rates may depend on many socio-economic factors, but it is beyond the scope of this paper.

The focus of this paper is to analyze potential convergence in crime rates at the regional level. We aim to contribute to the growing crime literature on Turkey by examining whether crime fighting socioeconomic policies should be constructed at a national or regional level. To do this, we employ different unit root tests to the total crime per 100000 habitants for 12 regions between 1990 to 2016 period. We categorize the crime types into four types as violent, property, drug, and the opposition of bankruptcy. In the first section, we introduce the previous researches on crime convergence within the broader framework that include determinants of crime convergence. Also, the limited literature of Turkey case studies is introduced at the end of the section. The remaining part of the study focuses on the empirical approach which is introduced by Carlino and Mills (1993). In this respect, we first assume the no-shift and sharp shift models for crime convergence. We then extent modeling by taking into account smooth shifts in the crime data. Lastly, we investigate the β-convergence for four types of crime.

This study has been organized as follows. Section 2 provides a brief overview of the previous research on crime convergence. Section 3 explains the data and empirical methodology. After, we present the findings with discussions of crime convergence. The last section is concerned with the summarizing and conclusion.

[4] The light imprisonment and light fine in laws are transferred to administrative fine according to the article 7/1 of Execution and Form of Application of the Turkish Criminal Law No. 5252 executed at 1 June, 2005. However, the sanction of uninformed property crime arranged in the article 337 of the Bankruptcy and Enforcement Law No. 2004 executed at 1 June, 2005 transferred to discipline imprisonment. Therefore, imprisonment has been applied instead of administrative fine applied as the sanction of uninformed property crime (TUİK, 2016).

2. Previous Researches on Crime Convergence

Although vast literature investigates the strength and the significance of the potential determinants of criminal activity and the impact of crime on the economy, there are very few studies on the examination of convergence in crime across regions. However, the sustained fluctuations starting in the 1970s in the crime rates in of US attracted the attention of researchers. In the USA, overall crime rates increased dramatically during the 1970s and reached a peak in 1980. After a steady decline in the mid-1980, there had been a continuous upward trend again until the early 1990s, then it peaked and tended to fall again.[5] The cyclical behavior of US crime data has led researchers to investigate whether there is a similar trend across regions. For example, utilizing city-level data for the US, some researches (e.g., Winsberg, 1993 and McDowall and Loftin, 2009) measured the correlation between individual states and national level crime rates and showed that nationwide pattern is very strong. Messner, Deane, Anselin, and Pearson‐Nelson (2005) analyzed the homicide crime behavior of cities for the years 1979 to 2001. Utilizing spline regression techniques, they showed that the majority of the cities exhibit similar trends in the USA while larger cities were more likely to experience an epidemic-like cyclical pattern of rapid increase followed by a sharp decline in homicide rates.

Contrary to these, analyzing the ten-year homicide rate trends in 32 US cities, Lattimore (1997) concluded that in contrast to the national trend in homicide rates, 14 of the 32 cities had increasing trends, 9 had decreasing trends and the remaining 9 cities showed no clear trend for the 1985-1994 period. Likewise, using simple ranking techniques, Becsi (1999) showed that there were significant variations between regions over the period 1971-1994. This study varies from the others because it also compared the determinants of crime rates at the regional level by using simple correlation techniques. Becsi (1999) found that while some states have high crime due to the relatively high unemployment rates, some others reflect rather demographic conditions, per capita income, etc.

Beyond these studies, another line of research considers that in some of the states, crime rates may persistently exhibit higher or lower values than others, however, in time, there may be a convergence or a divergence across regions. This approach is also quite instructive because if divergence is confirmed, the determinants of crime should be analyzed in regional context and accordingly policymakers should implement regional crime-fighting policies rather than nationwide. From this point of view, Cook and Winfield (2012) examined the possible presence of convergence in different types of crime across 50 states of the US over the period 1965 to 2009. Using β-convergence model, it was tested that whether regions with initially lower (higher) levels of crime experienced faster (slower) growth and

[5] See for more detail, Becsi, 1999.

found that there was a significant convergence in every type of crime with the highest degree of convergence witnessed for rape, larceny and property crime and the lowest level of convergence for murder. Cook and Winfield (2015) also estimated the same convergence model of Cook and Winfield (2012) for 6 regional units that are classified by population. The results of this study showed significant β-convergence for all cases, while the large metropolitan dataset exhibit a greatest degree of both violent and property convergence. Cook and Watson (2013) extended these analyses by taking into account breaks in the crime data and using a probabilistic approach to the analysis of convergence. For this purpose, firstly it is showed that all series except for burglary exhibit three clear regime breaks. Then, to determine whether there is a convergence between regions, firstly growth rates and initial levels of crime are divided into two regimes based on whether they are above or below the average value for the 50 states. Next, the probability of low (high) growth rates is influenced by low (high) initial levels are tested for seven types of criminal activity for three sub-samples. The results showed that convergence between regions varies depending on the form of crime and sample period. With another aspect, Baharom, Habibullah, and Royfaizal (2008) examined the violent crime convergence among fifty-one states in the US by using KSS-CHLL nonlinear unit root test of Chong, Hinich, Liew, and Lim (2008). It is showed that 41 states are diverging from the average crime rate in the United States which implies that differing crime-fighting policies are needed. A recent study for Brazilian states by De Almeida, Ehrl, and Moreira (2018) used the crime rates as a welfare proxy of social convergence. To better understand the mechanisms of social and economic convergence, they estimated the spatial error model (SEM) and the spatial autoregressive (SAR) model beside pooled OLS (POLS) and fixed effects. While the POLS estimation pointed out the convergence, the spatial models and FE model do not provide any evidence on β-convergence across Brazilian states. While some studies investigate the determinants of crime, a limited number of studies investigate the convergence of crime in Turkey case. The existing literature on determining the causes of crime focuses on the socio-economic factors, typically on income level, unemployment, and education. Using four subcategories of crime in Turkey over the period 1967-2004, Kuştepeli and Önel (2006) showed the existence of long-run relationship between the crime against property, crime against public and crime against state and government administration and socio-economic factors. Also, the results indicate that higher per capita income and lower education level increase three types of crime. Similarly, Cömertler and Kar (2007), for 81 provinces in 2000, and Dursun, Aytaş, and Topbaş (2011), for 26 sub-regions over the period 1990 to 2010, reported the similar significant relationship between per capita income and crime rates for Turkey. The latest study on the dynamics of crime in Turkey, Halicioglu (2012) analyzed the determinants of violent and non-violent crimes by time-series analysis. Crime rates are strongly related to per capita income and unemployment in the short and long run. Unlike previous studies, Halicioglu (2012) reported that an increase in per capita

income decreases the crime rate in the long run. Collectively, these studies highlight the significant relationship between crime rates, income level, unemployment, and demographic characteristics (e.g., education, urbanization) within the aspect of crime determinants.

There is relatively a limited body of literature that is concerned with the convergence of crime in Turkey. To our knowledge, a seminal study in this area is the work of Aslan and Öcal (2012) which analyzed the convergence and persistence of crime rates over the period 1998 to 2006 for 81 provinces of Turkey. They used sixteen crime subcategories, and the Im, Pesaran, Shin panel unit root test showed that homicide, defemination, theft, embezzlement, forestry crimes, crimes related with firearms and knives, misdemeanor crime rates converge within 81 provinces of Turkey. Lastly, Tunca (2018) investigated the existence of convergence and convergence rate of property crime for all provinces of Turkey between 2006 to 2016 by conventional ADF unit root test. He showed that the convergence rate is approximately 37% and the less developed regions or provinces' have higher convergence rates.

3. Data and Methodology

3.1. Data

We employ the annual convicts received into prison statistics in types of crime (hereafter, crime) for 12 regions of Turkey during the period 1990-2016. The data were obtained from the Turkish Statistical Institute (TURKSTAT). We prefer to use NUTS1 data and analyze the crime convergence by taking into account four types of crime because of the following reasons. First, the empirical literature on this topic indicates that the crime data should be taken as per 100000 inhabitants to get more accurate results for regional comparisons (e.g., Choe, 2008 and Cook, and Winfield, 2012). Therefore we took regional population data from TURKSTAT and calculated crime per 100000 inhabitants. The Turkish judicial system of crime classification includes 19 different types. However, the crime data for some years shows that there are no convicts received into prison for some types of crime for some cities. For example, no one was convicted in Van, Mus, Bitlis, Hakkâri, Urfa, and Diyarbakır because of the offense of libel in 2003. For that reason, we categorized the following types as being four main crimes:

1. Violent
2. Property
3. Production, commerce, use, and purchase of drugs
4. Opposition of bankruptcy and enforcement law.

We have reported descriptive statistics of these crime types in Table 1. These four types of crime are mostly committed crimes in Turkey. According to the TURKSTAT crime data, the average share of these four types of crime in total crime is 75.5% for the 1990-2016 period.[6] Eventually, to analyze whether there is a convergence in various types of crime among Turkey's regions, the relative regional crime per 100000 inhabitants is defined as $y_{i,t} = ln(\tilde{y}_{i,t}/p_{i,t})$ where $\tilde{y}_{i,t}$ is the crime numbers for the region i and $p_{i,t}$ is the regional population per 100000 inhabitants for all 12 regions.

Table 1: Descriptive Statistics

Types of crime	Violent	Property	Drug	Opposition of bankruptcy	Total crime
Mean	18114	15838	4457	30217	92589
Median	11857	13290	2605	27362	80096
Maximum	54118	36833	18312	66438	187719
Minimum	7572	7783	449	2222	44826
Std. Dev.	15517	8183	4869	14895	40077
Jarque-Bera	14.5	8.3	16.7	2.1	4.7
Observations	27	27	27	27	27

3.2. Methodology

To analyze the convergence of crime rates among Turkish regions, this study adapted the time series methodology of Carlino and Mills (1993). The standard econometric form estimated as follows:

$$y_{it} = \mu_i + \beta_i t + u_{it} \quad (1)$$

where y_{it} specifies the natural logarithm of total crime for 100000 inhabitants for region i at time t, β represents the deterministic rate of convergence over t, μ represents the initial level of y_{it}, and u_{it} is the error term. It is assumed that the error term is independently and identically distributed with zero mean and finite variance. If a region i is above its compensating differential initially, in other words if $\mu > 0$, it should grow slower than the nation (i.e., $\beta < 0$). This hypothesis known as the convergence hypothesis or β convergence (hereafter, β convergence).

According to Carlino and Mills (1993), convergence provides two conditions: stochastic and β-convergence. First condition requires shocks to y_t should be temporary (stochastic convergence). That implies y_t follows a stationary process in the time series modelling

[6] For more detail, see Appendix Table A.

framework. Second requires that initially poor regions should catch up with rich provinces (β-convergence).

Following Carlino and Mills (1993), this study first employs the Dickey-Fuller (DF) (1979) test to identify stationarity of y_t and estimate the following no-shift regression model by OLS:

$$\Delta y_t = Z_t'\delta + \alpha y_{t-1} + \varepsilon_t \quad (2)$$

In this model, Δy_t indicates the first difference of y_t, δ is the deterministic term of Z_t that defined by $[1, t]$, and ε_t is the error term. If the null hypothesis of unit root process $(H_0: \alpha = 0)$ is rejected against the alternative hypothesis of stationary $(H_1: \alpha < 0)$, this strengthen the favor of stochastic convergence. Perron (1989) indicates that Z_t is assumed not to have any structural changes in the no-shift model and to avoid misleading inferences in the existence of structural changes, Zivot and Andrews (1992) take into account a sudden structural break for the DF test. Hereupon, Narayan and Popp (2010) broaden Zivot and Andrews (1992) approach with two sudden breaks and require estimating the break dates.

In particular, the analysis of the sharp-shift models necessitates *a priori* knowledge for the dates, numbers, and form of breaks. However, the economic series may include multiple and non-sharp breaks that difficult to know as a priori. Enders and Lee (2012) present the smooth-shift model which extended the DF unit root test by a Fourier approximation which considers these difficulties. Unlike the previous approaches, a Fourier approximation allow Z_t to not require selecting the dates, number, and form of the breaks. The Fourier form of Z_t specification described trigonometrical as $\left[1, t, \sin(\frac{2\pi kt}{T}), \cos(\frac{2\pi kt}{T})\right]$ where k represents an integer frequency that order using the different critical values of the Fourier frequency. Even if the test statistic described as DF test, the distribution depends on k (Enders and Lee, 2012).

4. Findings

In order to designate the convergence of crime for 12 regions between 1990-2016, we used four main types of crime as being: violent, property, -production, commerce, use and purchase of drugs-, and opposition of bankruptcy and enforcement law.[7] To determine stochastic and β-convergence, we tested two conditions that are presented by Carlino and Mills (1993). Firstly, we revealed the stochastic convergence then carried out β-convergence assumptions for the regions where we have found stochastic convergence. For the first condition, we applied four different unit root tests that consider no-shift (DF,1979),

[7] The raw data are available from the authors on demand.

One-sharp structural break (Zivot and Andrews, 1992), two-sharp structural breaks (Narayan and Popp, 2010), and smooth-shift (Enders and Lee, 2012). For each region, we investigate the natural logarithm of total crime for 100000 inhabitants. In general, according to the context of unit root process, if crime rates do not have a unit root, in other words, follow a stationary process, shocks will be transitory and stochastic convergence will be supported.

Table 2: Results from no structural shift unit root test

	Violent		Property		Drug		Opposition of Bankruptcy	
Istanbul	-3.603	**	-2.821		0.251		-1.896	
West Marmara	-2.466		-1.991		-2.881		-3.210	*
Aegean	-1.599		-1.236		-3.305	*	-2.473	
East Marmara	-3.17		-3.142		-3.285	*	-2.788	
West Anatolian	-3.255	*	-1.954		-2.457		-1.934	
Mediterranean	-4.069	**	-2.649		-3.652	**	-2.952	
Central Anatolian	-3.345	*	-4.449	***	-1.538		-1.816	
West Black Sea	-4.716	***	-4.368	***	-2.888		-4.770	***
East Black Sea	-2.918		-4.168	***	-3.077		-2.928	
Northeast Anatolia	-3.558	**	-2.609		-4.795	***	-2.855	
Centraleast Anatolia	-3.645	**	-3.04		-3.152		-3.705	**
South East Anatolia	-0.501		-3.427	*	-2.082		-2.050	

Note: *, ** and *** denote statistical significance at 10, 5 and 1% levels, respectively.

Table 2 shows the results obtained from the conventional unit root analysis (hereafter, no shift test) of violent, property, production, commerce, use and purchase of drugs, and opposition of bankruptcy and enforcement law crimes for 12 regions. The no-shift unit root test results indicate that the null hypothesis of a unit root in crime rates is rejected for 7 regions for violent, 4 regions for property, 4 regions for drug, and 3 regions for opposition of bankruptcy and enforcement law crimes. Interestingly, there is no common region for all types of crime concerning no-shift results. In the period of 1990-2016, there have been significant changes in the number of convicted prisoners due to remission of punishment and financial crisis. Ignoring these breaks may yield misleading results. Thus, we continue our analysis by taking into account structural changes in different forms of models.

In order to investigate a sharp (sudden) structural break and two sharp breaks, we applied Zivot and Andrews (1992), and Narayan and Popp (2010) tests, respectively and the results are reported in Table 3. According to sudden shift unit root test results, it is apparent that violent crime convergence occurs in most of the regions.

The empirical results of one-sharp structural shift (two-sharp shift) indicate that the null hypothesis of unit root is rejected, put differently the stochastic convergence of crime exists, 8 (12) regions for violent, 5 (11) regions for property, 5 (11) regions for drug, and 7 (12) regions for opposition of bankruptcy and enforcement law crimes. The sharp shift test results present strong stochastic convergence for all types of crime. The most striking observation from two-sharp shift results is that nearly for all regions, convergence occurs in terms of all types of crime. The unit root tests which do not take into account the structural breaks and nonlinearity tend not to reject the unit root null hypothesis. Because of this tendency, we also applied Enders and Lee (2012) unit root test which takes into account the smooth-shift with Fourier approximation.

According to smooth shift unit root test results, the trigonometric terms are significant, so the series are stationary that supports the convergence hypothesis in 6 regions for violent and property, 8 regions for drug, and 5 regions for opposition of bankruptcy and enforcement law crimes.

If we take a closer look at the gradually shift tests results from Table 4, violent crime convergence occurs in Istanbul, East Marmara, Mediterranean, West Black Sea, Northeast Anatolia, and Central-east Anatolia. It is somewhat interesting that according to previous test results, in Istanbul, almost every type of crime convergence exist but smooth-shift test results show only violent crime converges. For the property crime, the null hypothesis of unit root is rejected in Aegean, East Marmara, West Anatolia, Central Anatolia, West Black Sea, and East Black Sea. These results are similar in number to previous test results, except two-sudden breaks results.

The stochastic convergence of drug crime dynamics is different from other types of crime that emerges in more region than the others. Drug crime convergence emerges in West Marmara, Aegean, East Marmara, Mediterranean, Central Anatolia, West Black Sea, Northeast Anatolia, and Centraleast Anatolia. The outcome of opposition of bankruptcy and enforcement law crimes convergence shows that convergence occurs in fewer regions than the other types. The stochastic convergence hypothesis is supported in Aegean, West Black Sea, East Black Sea, Northeast Anatolia, and Centraleast Anatolia. These results involve that the regions have the convergence of drug crime, except West and East Marmara.

Table 3: Results from the sharp-shift models

Violent	ZA		T_B	NP		T_{B1}	T_{B2}	Property	ZA		T_B	NP		T_{B1}	T_{B2}
Regions								**Regions**							
Istanbul	-4.897	*	1999	-6.501	***	1998	2004	Istanbul	-4.907	*	2007	-6.580	***	1999	2007
West Marmara	-7.934	***	2007	-8.894	***	2006	2009	West Marmara	-4.463		2010	-5.455	**	2000	2008
Aegean	-4.916	*	2007	-6.982	***	1997	2007	Aegean	-7.821	***	2005	-9.077	***	1996	2005
East Marmara	-4.989	*	2003	-7.453	***	1996	2006	East Marmara	-4.934	*	2000	-6.444	***	1996	2006
West Anatolia	-5.01	*	2007	-6.687	***	2003	2009	West Anatolia	-4.524		2006	-6.147	***	2001	2006
Mediterranean	-4.372		2005	-6.939	***	1999	2005	Mediterranean	-6.147	***	2007	-6.945	***	1997	2007
Central Anatolia	-4.832	*	2008	-5.310	**	2001	2008	Central Anatolia	-4.294		1996	-4.306		2002	2006
West Black Sea	-5.478	**	2007	-7.190	***	2004	2007	West Black Sea	-5.554	**	2007	-7.248	***	1999	2007
East Black Sea	-3.94		2011	-5.305	**	1998	2006	East Black Sea	-4.782		1999	-6.078	***	1999	2007
Northeast Anatolia	-4.335		1997	-6.789	***	1996	2003	Northeast Anatolia	-4.154		2003	-8.195	***	2002	2009
Central-east Anatolia	-7.966	***	1996	-7.942	***	1996	2007	Central-east Anatolia	-4.351		2008	-5.283	**	2003	2009
Southeast Anatolia	-4.529		2012	-7.640	***	2004	2009	Southeast Anatolia	-4.243		2001	-6.605	***	1997	2005
Drug								**Opposition of Bankruptcy**							
Regions								**Regions**							
Istanbul	-2.842		2008	-5.046	*	2000	2009	Istanbul	-6.691	***	2007	-7.078	***	2000	2007
West Marmara	-4.003		1999	-6.344	***	1996	2008	West Marmara	-4.122		2008	-5.911	**	1997	2004
Aegean	-4.886	*	2000	-6.392	***	2000	2007	Aegean	-4.832	*	2004	-8.807	***	2004	2007
East Marmara	-4.093		2009	-4.491		1998	2008	East Marmara	-4.793		2003	-7.710	***	2003	2006
West Anatolian	-5.449	**	2003	-6.550	***	1999	2003	West Anatolian	-3.348		2007	-6.300	***	2000	2009
Mediterranean	-4.615		2000	-5.476	**	1998	2009	Mediterranean	-4.757		2007	-6.285	***	2000	2007
Central Anatolia	-6.005	***	2005	-9.614	***	1997	2007	Central Anatolia	-5.595	***	2004	-6.063	***	1998	2004
West Black Sea	-4.225		1999	-4.975	*	1999	2008	West Black Sea	-7.004	***	2009	-10.42	***	2003	2006
East Black Sea	-5.236	**	2004	-6.243	***	2001	2008	East Black Sea	-6.103	***	2007	-7.487	***	1996	2007
Northeast Anatolia	-6.606	***	2005	-7.562	***	1999	2007	Northeast Anatolia	-4.91	*	2002	-6.874	***	1999	2006
Central-east Anatolia	-4.328		2000	-6.849	***	1997	2008	Central-east Anatolia	-5.998	***	2007	-7.389	***	2003	2006
Southeast Anatolia	-5.244	**	2006	-6.022	***	1996	2005	Southeast Anatolia	-7.257	***	2003	-7.338	***	1998	2003

Note: ***, **, and * denote statistically significance at the 1%, 5% and 10% levels, respectively.

ZA: Zivot and Andrews (1992). NP: Narayan and Popp (2010).

Taken together, the findings indicate that the conventional unit root test -not account for any structural change- supports strong evidence on the divergence for property, drug, and opposition of bankruptcy. The unit root tests with two sharp breaks provide strong evidence on the crime convergence, and the unit root approach with a gradual/smooth structural shift does not show clear-cut evidence on divergence. The critical issues are existing from gradual structural shift findings that the shocks on all four types of crime are temporary for a considerable amount of regions. This finding is contrary to that of Aslan and Öcal (2012) who found no evidence on stochastic convergence of drug and opposition of bankruptcy crimes.

Table 4: Results from the smooth-shift model

Violent	$\widehat{k}$	**t-ratio**		**Property**	$\widehat{k}$	**t-ratio**	
Regions				**Regions**			
İstanbul	3	-4.364	**	İstanbul	1	-3.727	
West Marmara	3	-2.775		West Marmara	2	-2.474	
Aegean	1	-3.610		Aegean	1	-7.768	***
East Marmara	1	-4.348	*	East Marmara	2	-5.249	***
West Anatolian	1	-3.926		West Anatolian	1	-4.406	**
Mediterranean	1	-4.074	*	Mediterranean	1	-3.403	
Central Anatolian	1	-3.595		Central Anatolian	3	-5.869	***
West Black Sea	1	-5.198	***	West Black Sea	2	-4.899	***
East Black Sea	2	-2.955		East Black Sea	3	-4.780	***
Northeast Anatolia	2	-5.468	***	Northeast Anatolia	1	-3.698	
Centraleast Anatolia	1	-5.315	***	Centraleast Anatolia	2	-3.513	
Southeast Anatolia	1	-3.915		Southeast Anatolia	3	-1.772	
Drug				**Opposition of Bankruptcy**			
Regions				**Regions**			
İstanbul	1	-2.695		İstanbul	2	-2.899	
West Marmara	2	-6.505	***	West Marmara	2	-3.640	
Aegean	1	-4.154	*	Aegean	1	-4.438	**
East Marmara	2	-4.060	**	East Marmara	1	-3.412	
West Anatolian	2	-3.290		West Anatolian	1	-3.568	
Mediterranean	3	-4.249	**	Mediterranean	2	-3.651	
Central Anatolian	1	-7.562	***	Central Anatolian	1	-3.941	
West Black Sea	2	-4.493	**	West Black Sea	3	-4.142	**
East Black Sea	1	-3.651		East Black Sea	2	-5.093	***
Northeast Anatolia	2	-5.842	***	Northeast Anatolia	1	-4.533	**
Centraleast Anatolia	2	-5.862	***	Centraleast Anatolia	1	-4.428	**
Southeast Anatolia	3	-2.386		Southeast Anatolia	1	-3.762	

Note: ***, **, and * denote statistically significance at the 1%, 5% and 10% levels, respectively.

Carlino and Mills (1993)'s second condition for convergence defines that the stochastic convergence is necessary but not sufficient for convergence. To put a finer point on this condition-convergence also requires that a region with crime below the national average must grow more than the national crime rate- which is defined as β-convergence. Thus, we

also investigate β-convergence to find out whether the regions with stochastic convergence supported by smooth-shift model. If $\mu > 0$ then $\beta < 0$ or if $\mu < 0$ then $\beta > 0$, put differently if there is a negative relationship between β and μ, that supports β-convergence. In order to reveal this relationship, we estimate the equation (1) following Tomljanovich and Vogelsang (2002). The results from β-convergence estimations are shown in Table 5.

Table 5: Results from β-convergence estimations

Crime Type	Region	μ	$t-stat$	β	$t-stat$	Decision
Violent	İstanbul	-0.090	-1.298	-0.012	**-2.708**	D
	West Marmara	0.340	11.911	0.001	0.384	D
	Aegean	0.309	11.023	0.002	1.240	D
	East Marmara	0.164	**6.047**	-0.005	**-2.735**	C
	West Anatolian	-0.051	-1.318	-0.002	-0.718	D
	Mediterranean	0.154	**8.395**	0.000	-0.083	D
	Central Anatolian	-0.080	-2.096	0.011	4.685	D
	West Black Sea	0.118	**5.484**	0.001	0.670	D
	East Black Sea	-0.259	-5.338	0.006	1.903	D
	Northeast Anatolia	-0.294	**-5.769**	0.008	**2.627**	C
	Centraleast Anatolia	-0.504	**-14.680**	-0.003	-1.257	D
	Southeast Anatolia	-0.173	-4.269	-0.017	-6.702	D
Property	İstanbul	0.943	8.886	-0.028	-4.249	D
	West Marmara	-0.010	-0.205	0.005	1.521	D
	Aegean	0.448	**8.895**	-0.003	-0.965	D
	East Marmara	0.350	**10.670**	-0.006	**-3.085**	C
	West Anatolian	0.368	**7.383**	-0.005	-1.685	D
	Mediterranean	0.162	5.223	0.006	2.977	D
	Central Anatolia	-0.356	**-6.747**	0.011	**3.334**	C
	West Black Sea	-0.424	**-8.296**	0.006	**1.926**	C
	East Black Sea	-0.775	**-12.439**	0.007	1.795	D
	Northeast Anatolia	-1.099	-11.595	0.028	4.758	D
	Centraleast Anatolia	-1.117	-18.526	0.020	5.394	D
	Southeast Anatolia	-0.611	-9.155	0.011	2.608	D
Drug	İstanbul	1.173	14.399	-0.022	-4.258	D
	West Marmara	-0.271	**-4.097**	0.002	0.470	D
	Aegean	0.140	**2.591**	0.004	1.157	D
	East Marmara	-0.180	**-2.829**	-0.003	-0.696	D
	West Anatolia	-0.555	-6.483	0.014	2.576	D
	Mediterranean	-0.090	-1.671	0.028	8.430	D
	Central Anatolia	-1.374	**-7.789**	0.032	**2.930**	C
	West Black Sea	-0.915	**-8.415**	0.005	0.751	D
	East Black Sea	-1.836	-11.741	0.031	3.214	D
	Northeast Anatolia	-1.994	**-8.392**	0.058	**3.919**	C
	Centraleast Anatolia	0.636	**8.859**	-0.012	**-2.756**	C
	Southeast Anatolia	0.591	8.548	-0.019	-4.403	D
Opposition of Bankruptcy	İstanbul	-0.039	-0.300	-0.037	-4.473	D
	West Marmara	0.658	10.268	-0.001	-0.226	D
	Aegean	0.771	**9.933**	-0.007	-1.443	D
	East Marmara	0.652	7.282	-0.018	-3.191	D
	West Anatolian	0.567	4.987	-0.036	-5.140	D
	Mediterranean	-0.318	-6.738	0.025	8.500	D
	Central Anatolian	-0.307	-5.757	0.016	4.892	D
	West Black Sea	-0.285	**-4.452**	0.030	**7.493**	C
	East Black Sea	-1.163	**-12.439**	0.025	**4.274**	C
	Northeast Anatolia	-1.103	**-9.736**	0.021	**3.015**	C
	Centraleast Anatolia	-0.830	**-4.111**	-0.038	**-3.034**	D
	Southeast Anatolia	-1.365	-10.515	0.017	2.049	D

Note: D: Divergence. C: Stochastic and β-convergence. Bold values present the significance of the coefficients.

The findings on the negative relationship between μ and β support the convergence for 2 regions in violent, 3 regions in property, drug and opposition of bankruptcy. For example, in Northeast Anatolia, the results show the evidence on convergence for 3 types of crime: violent, drug and opposition of bankruptcy. What stands out in the results for Northeast Anatolia is $\mu < 0$ and $\beta > 0$ for all 3 types of crime. This result shows the evidence on β-convergence which point out Northeast Anatolia's crime rates grow faster than national average crime rates. Further, we may see the same evidences on convergence from above in Central Anatolia, West Black Sea, and East Black Sea for property, drug and opposition of bankruptcy crime. In contrast, the findings on $\mu > 0$ then $\beta < 0$ corroborated only for two regions East Marmara and Centraleast Anatolia. In East Marmara, the existence of convergence is seen for violent and property crimes, and all two are featuring convergence from below. Interestingly, there is only one crime convergence in Centraleast Anatolia, and this belongs to convergence from below for drug crime. This stands out for East Marmara and Centraleast Anatolia the crime rates grow more slowly than the national average.

The results demonstrate property crime convergence in the East Marmara, Central Anatolia, and West Black Sea and confirm the findings of Tunca (2018), which examines property crimes only, that the existence of convergence in provinces of these regions. Though, while this study investigates the rate of convergence, our study focuses on convergence from above and below. We provide a detailed summary of β convergence in Table 6.

Table 6. Summary of β convergence results

Region	Violent	Property	Drug	Opposition of Bankruptcy
İstanbul				
West Marmara				
Aegean				
East Marmara	CFB	CFB		
West Anatolia				
Mediterranean				
Central Anatolia		CFA	CFA	
West Black Sea		CFA		CFA
East Black Sea				CFA
Northeast Anatolia	CFA		CFA	CFA
Centraleast Anatolia			CFB	
Southeast Anatolia				

CFB: Convergence from below CFA: Convergence from above

There is a remarkable outcome about the findings is that 5 out of 12 regions have convergence for at least one type of crime and are corroborated by convergence from above on a large scale. In other words, crime rates are growing faster than the national average for these regions. In particular, the opposition of bankruptcy has the characteristics of convergence from above in these 3 regions. Besides, in Central Anatolia, West Black Sea and Northeast Anatolia regions, it is seen that every type of crime rates is growing faster than the national average for each region that indicating significance in favor of convergence.

5. Conclusion

In this paper, we investigate the crime convergence in 12 regions of Turkey using data for the 1990 to 2016 period. We categorized the crime types into four main types which are violent, property, drug, and opposition of bankruptcy. The aggregated crime data of Turkey indicate that total crime per 100000 inhabitants has increased by approximately 190% between the period 1990-2016. In this period, there have also been significant changes in the number of convicted prisoners due to remission of punishment or financial crisis.

This paper aims to extend the literature on crime convergence by focusing on time series unit root analysis. An attempt is given to whether controlling for structural shifts plays an important role and whether different approximations to modeling breaks leads to different results and hence policy implications. Therefore, it is promoted to analyze the convergence with approaches that take into account breaks that are showing the behavioral changes in crime rates (Cook and Cook, 2011; Cook and Winfield, 2013). In that respect, we follow

Carlino and Mills (1993) which argue that two conditions are required for convergence. First one is called stochastic convergence which is defined as shocks to y_t should be temporary. The second condition is β-convergece that requires initially, regions with lower crime rates should catch up regions with high crime rates

To shed light on the crime convergence of Turkey, we investigate the convergence hypothesis in Turkey using conventional and newly developed time series techniques. The conventional ADF approach implies that almost 75% of Turkish regions diverge from the national average. This finding provides a room to implement region-specific measures to decrease inter-regional crime differences. The new techniques take into consideration the effects of sharp (one or two) shifts or smooth shifts in the crime rates. The sharp shift testing tools show strong evidence on crime convergence. However, the smooth shift testing does not show clear-cut evidence for the crime divergence. However, β-convergence testing supports strong evidence in favor of crime divergence. These results indicate that there is a crime convergence where located especially in Anatolian and Black Sea regions. Moreover, middle and western regions have crime divergence feature. In conclusion, the empirical analysis implies that controlling for structural shifts plays an important role, and modeling breaks with different approximations lead to changes in inferences.

Consequently, in addition to the determination of convergence of the various crimes in which regions, this study also focuses on the type of convergence from below or above. The results of convergence in Central Anatolia, West Black Sea, East Black Sea, and Northeast Anatolia show that crime rates in these regions are growing faster than the national average. In contrast, the presence of convergence in East Marmara and Centraleast Anatolia indicates that crime rates in these regions are growing slower than the national average. These outcomes strengthen that a single type of crime fighting policy for different regions and types of crime may lead to ambiguous results. As a policy implication, these results suggest that the inter-regional socio-economic policies to decrease crime rates in regions should be needed in Turkey. Further researches should be required to investigate the determinants of crime in regions where convergence exist to reveal a key policy priority.

Appendix

Table A: Annual convicts received into prison statistics by crime types

		(1)	(2)	(3)	(4)	
Year	Total crime	Violent	Property	Drug	Opposition of bankruptcy	(1)+(2)+(3)+(4) %of total crime
1990	44787	8897	7783	1068	16890	77.3
1991	53864	8506	7958	812	27328	82.8
1992	54340	7572	8959	449	27169	81.2
1993	53543	7717	7839	570	27511	81.5
1994	60656	8761	8613	773	31385	81.7
1995	63015	8918	9192	1102	30948	79.6
1996	61022	9058	9622	1359	27368	77.7
1997	62836	9275	10459	1630	26888	76.8
1998	68993	9731	11609	1801	30504	77.8
1999	83396	9683	11909	2012	43954	81.0
2000	98862	9241	13290	2418	56931	82.8
2001	112155	9928	11809	3147	66438	81.4
2002	98860	11759	9251	3450	49368	74.7
2003	99754	11857	11082	3705	46761	73.6
2004	101179	13862	16987	3764	40323	74.1
2005	52539	12364	18395	1909	2222	66.4
2006	77653	12513	18062	2366	24569	74.1
2007	127101	18064	20904	4492	55323	77.7
2008	76580	16645	19228	4199	18175	76.1
2009	74361	12039	16580	2605	19872	68.7
2010	88464	14121	17961	4415	27362	72.2
2011	80096	16202	16494	4131	24805	76.9
2012	115496	30299	14591	7974	30518	72.2
2013	161711	51529	24806	11851	18701	66.1
2014	170731	54118	33538	14341	14021	68.0
2015	168726	53317	33873	15675	13024	68.7
2016	187719	53089	36833	18312	17488	67.0

Source: TURKSTAT

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