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A spatial panel data analysis of crime rates in EU

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Abstract

The study investigates selected factors affecting crime rates in the EU-15 countries during the years 2000 to 2007 with an especial focus on inflation rate, level of education, income and employment. While these topics have been investigated in former studies, the present study adds by introducing spatial panel data methods to the case. Regarding the effects of these factors, the present study obtains results comparable to those from former studies, whereby the robustness of these are confirmed.

Keywords: determinants of crime rates, cost-benefit analysis of crime, EU countries, spatial panel data analysis.

JEL classification: A120, C500, K4

1. Introduction.

It is generally accepted that crime damages societies psychologically as well as economically. Therefore, various aspects of crime, including factors determining crime, matters related to punishment of crime etc., have always had an important place in research disciplines like psychology, biology, sociology, law and economics. Scholars from different disciplines have aimed at exploring the determinants of crime and thus contributed to the efforts exerted by authorities in order to decrease crime. A large number of studies have revealed a variety of factors that affect crime rates, including demographic characteristics, economic and sociological conditions, public regulation etc. However, given that these studies apply different methods and involve data from different countries and sources, a general consensus regarding the reasons of crime has not yet been reached.

It is well known that crime inflicts important externalities for the economy due to the costs and the social deterioration caused by it. As the government applies punishment policies in order to prevent crime, money is spent on prisons, courts, judges, prosecutors and police forces (Donohue 2007). These basic or direct costs caused by crime tend to increase if the crime rate increases (Tella and Schargrodsky 2004). In addition, a number of indirect costs are inflicted, such as productivity loss in labour market, losses in human and social capital stock and costs caused by a decreasing rate of participation in labour market activities (Fajnzylber et al. 2000). Furthermore, a number of costs for protection against crime are inflicted including security guards, lock systems, alarm systems, self protection etc. (Clotfelter 1977; Becker 1968). Cohen (2005) divides the costs of crimes for the victims into tangible and intangible costs. Tangible costs include items like work and productivity loss for the victim, work and productivity loss for the victim's family members, loss due to being unable to attend school, health costs due to any

injuries, spending made in order to get over mental disorders due to the shock experienced and loss of property. Intangible costs are defined as decreasing life quality of the victim due to the incident experienced.

Given its negative effects on society as well as individuals, prevention of crime is an important matter. To this end, the determining factors of crime must necessarily be explored, followed by the necessary precautions as determined in light of these factors. Given that many studies have questioned the effects of social, economic and demographic variables on crime rates, a general consensus regarding the ultimate reasons of crime has not been (and, presumably, will never be) obtained.

The present study reviews existing knowledge regarding factors determining crime rates. Next, we contribute with a replicating investigation based on data from 15 EU countries for the years 2000 to 2007. Our especial focus is on selected factors (GDP per capita growth rate, inflation, level of education, urbanization rate and labour force participation rate). While the effects of these factors on crime have been investigated in previous studies, our specific contribution will be a closer examination of the robustness of these results by applying spatial panel methods. Following a brief presentation of the economy of crime in Section 2, Section 3 will review factors determining crime, while methodological matters are briefly outlined in Section 4 and the data presented in Section 5. Finally, the results are presented in Section 6 and rounded off by a brief discussion in Section 6.

2. The economy of crime.

While crime and related societal problems were early mentioned by social researchers like Adam Smith and Karl Marx, Becker (1968) was the first attempt to specify an economic model of

crime. This early attempt was later elaborated on by numerous authors, including Ehrlich (1973), Schmidt and Witte (1984), Witte (1980) and Myers (1983).

Becker (1968) considers crime as an economic activity which bears high risks and high yields. The study argues that those who commit crimes base their decision on a cost- benefit analysis and then decide to commit crime if the profit is bigger than the cost. Becker defines benefit as the income obtained by an illegal act, and cost is composed of the loss of earnings from alternative legal work, losses inflicted by the risk of getting caught, and potential costs caused by imprisonment and punishment. Under these conditions, individuals are assumed to commit a crime if the expected benefit from the crime is larger than the expected cost. On the other hand, if the expected cost is larger than the expected benefit, individuals are expected to turn to legal activities and thus change the opportunity cost to a profit generated by the legal acts that they otherwise had to abandon if they committed the crime (Witte and Witt 2002; Grogger 1998; Doyle et al. 1999).

Thus, the economic model apparently has a unique approach to crime as compared to models and approaches from criminology, psychology, sociology and other disciplines. The economic approach perceives crime just like any other economic activity that costs time and effort and yields monetary benefit. This implies that individuals regard crime and work as substitutes (Witte and Tauchen 1994). In other words, the decision of committing a crime is not qualitatively different from the decision of buying a good. Just as, *ceteris paribus*, an increase in the price of a good decreases the demand for it, the cost of crimes might be increased in order to reduce the crime rate. Moreover, in the economic approach criminal individuals are regarded to be rational and to maximize their economic prosperity (Schmidt and Witte 1984). However, the economic

approach relies on an assumption of full information. Typically, the consequences of criminal acts, alike the risk of being arrested and imprisoned, are not (or only vaguely) known in advance.

The mechanisms underlying the decision to commit a crime can be explicated as follows (Warren 1978). Let X denote the income to be obtained by an individual through legal acts, and Y the income to be gained through a crime. Next, p denotes the probability of being caught and sentenced, and Z the pecuniary consideration of the punishment if he caught and sentenced. The benefit to be obtained by legal acts is denoted by $U(X)$, and the benefit obtained from crime by $U(Y)$. Given that the benefit to be obtained from crime depends on whether the individual is caught or not, the expected benefit from crime $E(U)$ is obtained by multiplying the benefit of crime if not caught by the probability of not being caught, and add the benefit of crime if caught multiplied by the probability of getting caught. Thus,

$$E(U) = (1-p)U(Y) + pU(Y-Z).$$

Accordingly, poor individuals with low incomes (i.e. small X values and consequently low $U(X)$ values) are supposed to commit crimes with a higher probability. Moreover, those who have been imprisoned for a while are strongly expected to commit other crimes. This follows readily, as $U(X)$ should be larger than $E(U)$ in order to refrain from crimes. Thus, a prevention of crimes may be obtained by increasing X , p or Z . However, for imprisoned individuals, it is not easy to increase X , given the lack of occupational and educational opportunities in this situation. Furthermore, given of the notoriety of imprisoned individuals, it is pretty hard for these to get a high salary or even a job. Next, it may be difficult to increase the risk of getting caught and sentenced, as imprisonment and other experience gained from former crimes may learn individuals to become more professional criminals in the future. Thus, imprisonment may readily

decrease p , which in turn drives $U(X)$ to be smaller than $E(U)$, whereby convicts will tend to commit crimes again. In sum, it is questionable whether individuals will refrain from future crimes after punishment (Warren 1978).

The economic approach to crime has several advantages compared to other disciplines. One important advantage is that the factors determining crime are assumed to be external. This implies that in case of disagreement about the assumptions concerning these factors, the point of disagreement will be external and inference of models based on different assumptions can be analyzed. In many other social disciplines, the assumptions are internal, so that such an approach is not feasible for them. Another important advantage is that the variables of the economic approach are economic indicators, which are measurable. On the other hand, a major important criticism against the economic approach is that it only considers economic factors determining crime and commonly excludes non-economic factors. Furthermore, the inference suggested by the economic approach is commonly criticized for being too specific. Moreover, many social disciplines may be less sensitive towards assumptions than economics. Specifically, the former take an individual sample of crime and make inferences about the illegal behaviour of the individual, based on their behaviour, while the point of departure for the economic analysis is the latent decision by the individual whether or not to commit a crime (Warren 1978).

3. Factors determining crime.

Crime is as old as mankind and it has become a major problem for governments. Thus, an important objective of authorities is to prevent illegal activities. As a consequence, the factors causing crime have also been vastly investigated, as a proper knowledge of these is necessary in order to prevent crime. Within the economic model tradition, the major factors affecting crime

are predominantly considered to be economic, including level of education, level of income, income inequality, unemployment, urbanization rate, young population, female/male population rate, labour force participation rate, number of polices, security expenditures, crime history of individuals etc.

Many empirical studies have considered the effects of socio-economic and demographic factors on crime rates. A variety of methodological approaches have been applied, and different time periods and countries considered. This may partly explain why a lack of consensus, and even conflicting results, are found in the literature regarding the effects of these factors. One example is gross domestic product (GDP), which is commonly used as a measure of income and which is commonly expected to have a negative effect on crime. In many studies investigating factors affecting crime (e.g. Ehrlich 1973; Kelly 2000; Imrohoroglu et al. 2006) income appears as a basic explanatory variable. It is obviously expected that individuals with low income present higher rates of crime involvement. According to the opportunity cost consideration of the economic approach, an increase in income would raise the opportunity cost of crime involvement and thus decrease the tendency to involve in crime. However, Fajnzylber et al. (2002) evaluates the matter differently and assert that crime rates might increase despite the increase in per capita income. Their explanation is that as the wealth of other members of society grows with economic development, the potential income from crime would also increase. Furthermore, the welfare level of those people whose income decreases or remains unchanged despite the general increase in per capita income would decline in relative terms. In other words, despite the increase in per capita income the welfare of some citizens would decline due to the increased inequality in the income distribution. Moreover, widespread technological innovations and easier communication opportunities during economic growth periods might facilitate crime involvement and lead to an

increase in crime rates (Fajnzylber et al. 2002). Mera and Jayakumar (1995) assert that moral values might decline due to the impact of increasing economic welfare and a materialist way of life take over. Cero and Merloni (2000) studied 22 Argentinean provinces between 1990 and 1999 aiming at investigating factors that might determine crime. In contrast to theory, they revealed that increasing income was related to increasing crime rates. Gumus (2004) focused on factors determining crime in USA and found that per capita income, inequality, urban population, black population and unemployment were significant such factors.

Another important factor determining crime is inflation rate. Despite its relevance, however, many studies of crime do not include it. Among exceptions are studies by Curtis (1981), Ralston (1999), Teles (2004) and Tang and Lean (2007) where inflation was investigated as a potential determiner of crime. As inflation weakens purchasing power, individuals may purchase lesser goods with a given income. This may potentially worsen their life standard and thus stimulate the individuals to pick crime as a source of extra resources. Thus, as pointed out by Teles (2004), as income affects preferences concerning crime, and as inflation decreases the real income, it is clear that income encourages to crime involvement.

Furthermore, it is known that low income groups are most severely influenced by increasing inflation. Thus, inflation causes people with low incomes to be more susceptible to crime, unless their wages are increased. However, wages cannot adjust to inflation as rapid and easy as other prices (Seals and Nunley 2007). Another study that points out the delay in reaction of wages to inflation is Devine et al., (1998). For situations where the real income of unskilled workers decrease due to inflation, Long and Witte (1981) showed that illegal activities with higher profit might potentially be preferred. In extension of this, Devine et al. (1998) noted that problems of maintaining social control may occur, as inflation potentially erodes the trust in existing

agreements among institutions and individuals. Thus, Curtis (1981) observed that minorities and the poor are affected more severely by inflation than other members of the society, which might motivate them for committing crimes.

Ralston (1999) studied the period 1958 to 1995 in USA and supported theory by showing a positive relationship between inflation and crime rates. Tang and Lean (2007), who also studied USA, found a similar positive relationship between inflation and crime rates as well as a long term co-integration between them. Similarly, Deadman and MacDonald (2002) found in a study USA that in a process where economic growth continues, a decrease in inflation is related to a decrease in crime rates. Another study by Seals and Nunley (2007) asserted that inflation is a significant driver of crime. Specifically, they found that inflation rate and crime rate were correlated during the 1960s and the 1970s as well as in the 1990s. Tang (2009) studied Malaysia and found that inflation during the period 1970 2006 period was a significant driver of crime. In the same study, a co-integration test revealed a long term relationship between inflation and crime. Similarly, Gillani et al. (2009), who did a similar analysis for Pakistan, asserted that inflation and poverty enters a long term relationship with crime.

Furthermore, crime rates are related to urbanization. Theoretically, an increase in the urbanization rate is supposed to bring along an increase in the crime rate. Given that in big cities the risk of getting caught is low, and thus the benefit to be received through the crime is high, such an expectation was suggested by Masih and Masih (1996) and Helsley and Strange (1999). Glaeser and Sacerdote (1999) showed that the high benefits to be potentially received in big cities increased the crime rates there by some 25 percent. Moreover, the outskirts of big cities may potentially be areas where migrants from the country side settle. Such migrants are typically used to the life in an agricultural society and therefore experience difficulties in adopting the

industrialized life style of the big cities. Thus, such outskirts are the typically parts of the town where the crime rates are high. Furthermore, in these parts of the city, it is commonly seen that the living standard is low and that the unemployment rate is high. In sum, individuals living in the outskirts, being marginalized and experiencing hard living conditions, might be motivated for criminal activities.

Educational level is yet another important factor affecting crime. A negative relationship between education and crime has been suggested and may partly be related to income, as individuals with high level of education generally have well paid and respectable jobs. This implies that the opportunity cost of committing crime is higher for educated people. Lochner and Moretti (2004) indicated that educated people care may care even more about their respectability than about their income. Besides, as shown by Fajnzylber et al. (2002), education is one of the most important sources of civilization. In this context, Lochner and Moretti (2004) underlined that educated people act calmer and more reasonable, they are more patient, and they are risk averse. Thus, as education increases, the perception of problems, of factors leading to crime and of crime itself may change. In other words, moral and social values may improve, whereby the preferences regarding crime may change. Similarly, Usher (1997) asserted that educational institutions promote social values, grow up individuals as hardworking and honest people, and raise their cultural and moral values in favour of the society.

While traditional studies of education focused on the personal benefits of receiving it, later economic studies also focused on societal outcomes of education. Thus, given that crime causes large social costs, education is most helpful as it results in an important decrease in these social costs (Lochner and Moretti 2004). Along these lines, Moretti (1999) showed that workers with

high levels of education increase the income of the other workers around them, which may provide a further reduction of crime.

However, the studies so far have to some extent reached conflicting results regarding the relationship between education and crime. For example, Lochner (1999), reached significant results consistent with theory while Grogger (1998) and Marselli and Vannini (1997) found insignificant results. Witte and Tauchen (1994), on the other hand, asserted that in order to prevent crime the engagement in legal activities like education or employment was far more effective than the income to be received from these activities.

Finally, crime rates are naturally affected by unemployment, which in turn is determined by the (mis)match between labour force size and employment capacity of the society. Specifically, the proportion of inhabitants in the age group 16 to 65 years who are able to work, denoted the labour force contribution rate, should match the employment capacity of society. If the latter is large enough, then the active population is able to obtain a satisfying legal earning. However, if the employment capacity is too low, then some of the unemployed people might commit crimes for money (Blackmore 2003). Thus, unemployment is included as a determining factor for crime.

4. Methods

Given that panel data contain the two complementary dimensions of cross section and time, they typically provide more information and variability as compared to one-dimensional data. Thus, analyses carried out using panel data typically offer an increase in the degrees of freedom and a decrease in the potential collinearity problems among the explanatory variables (Hsiao: 2005). Hence, panel data provide more effective estimates. Panel data models have a heterogeneous structure due to unobservable or excluded effects. A one-way specification considering

heterogeneous individual effects may be formulated. Whether this effect would be stable or random is much debated in both methodological studies and several applied studies (Wooldridge 2010). According to the assumptions concerning these effects, panel data models are classified as fixed effect and random effect models. Furthermore, for cases where panel data contains a locational component a spatial dependence might be present in the observations (Elhorst 2003). Spatial dependences are commonly expressed through a weight matrix which specifies the neighbourhood relations. Such a matrix is commonly assumed to remain constant through time (Anselin et.al 2008). Thus, for a panel data model with N regional units T time periods, a weight matrix with NT by NT dimensions that contains neighbourhood relations is given by

$$W = I_T \otimes W_N \quad (1)$$

where I_T is a T dimensional identity matrix and W_N the N by N spatial weight matrix for one year. For the fixed effect models, the individual effect is captured using dummy variables for each region. Spatial fixed effect models are further classified into fixed effects spatial lag model and fixed effects spatial error model by the type of spatial dependency they contain. The fixed effects spatial lag model (Elhorst 2003) reads as

$$y_t = \rho W_N y_t + X_t \beta + \alpha + u_t \quad (2)$$

where y_t is an N dimensional vector of observations for the dependent variable, X_t an N by K matrix of explanatory variables, ρ the spatial spillover parameter, β a K dimensional vector of regression coefficients, α an N vector of individual fixed effects, and u_t an N dimensional vector of white noise residuals. Model (2) is estimated by maximum likelihood methods after

demeaning y_t and X_t . Alternatively, a spatial error variant of the fixed effects model reads as (Elhorst 2003)

$$y_t = x_t\beta + \alpha + u_t, \text{ with } u_t = \lambda W_N u_t + \varepsilon_t \quad (3)$$

where λ denotes the spatial spillover parameter. Similar to (2), the model (3) is estimated by maximum likelihood methods.

An alternative to the fixed effect specification is a random effects model based on the assumption that individual effects are random. Thus, a random effects spatial lag model (Elhorst 2003) is given by

$$y_t = \rho W_N y_t + x_t\beta + v_t \quad (4)$$

where the N dimensional residual vector v_t reads as $v_t = \alpha + u_t$ with the definitions otherwise as above. For any two time periods t and s , the covariance matrix of v_t and v_s reads as $\Omega_{ts} = E(v_t v_s') = \sigma_\alpha^2 I_N + \sigma^2 I_N$ if $t = s$ and $\Omega_{ts} = E(v_t v_s') = \sigma_\alpha^2 I_N$ otherwise. Again, the spatial effect may be captured alternatively by specifying a random effects spatial error model (Elhorst 2003) reading as

$$y_t = x_t\beta + v_t \quad (5)$$

with the residual specification $v_t = \alpha + B^{-1}u_t$, where $B = (I_N - \lambda W)$, with definitions of terms otherwise as above. Alike the fixed effects specifications, the two random effects specifications.

5. Data

The present study aims at investigating the factors determining crime according to the models of Becker (1968) and Ehrlich (1973) for the case of 15 European Union countries (denoted EU-15¹). Thus, economic and social factors hypothesised to determine crime for the EU-15 countries between the years 2000-2007 were collected. The data came from World Bank's World Development Indicator database and Eurostat.

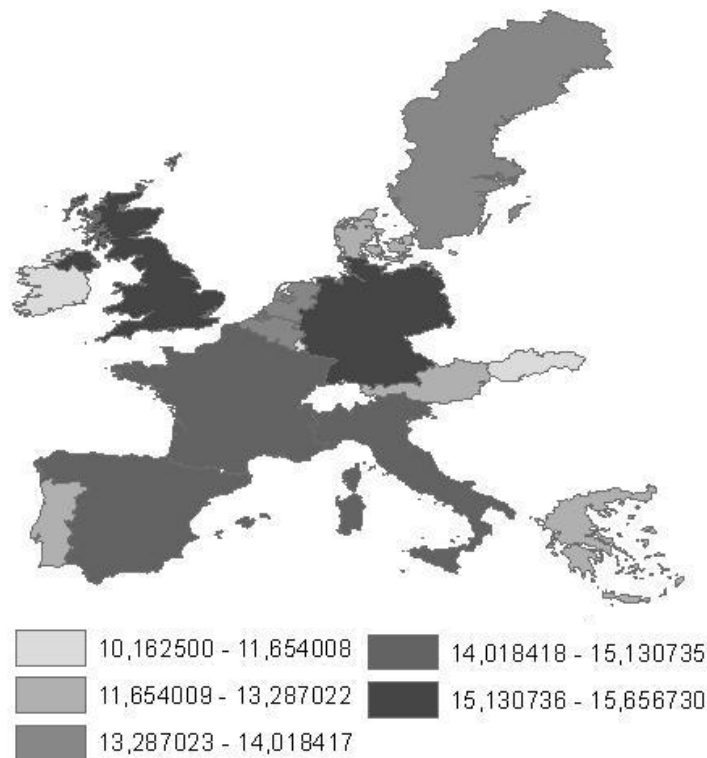


Figure 1. Spatial distribution of crimes recorded by police for 2007.

Crimes against property and violence-based crimes are commonly assumed to be affected by different factors. As notified by Scorcu and Cellini (1998), while economic variables are efficient

¹ EU-15 covers Denmark, Belgium, Ireland, France, Germany, Italy, Greece, United Kingdom, Sweden, Spain, Portugal, Netherlands, Luxembourg, Slovakia and Austria.

and significant in case of crimes against property they are not expected to be significant in violence crimes. However, due to shortness of data the analysis variable is taken as total crime rate or crime rate per capita. The present study applies a log transform of the crime rate. As a proxy variable for crime, the number of crimes recorded by police is applied. Figure 1 shows the distribution of this variable across countries for the 2007 data. It is evident that spatial spillover is present.

Turning to the explanatory variables, the growth rate of per capita gross domestic product (GDPG) is applied as an indicator of economic growth and welfare, while demographic data is made up by the rate of population aged 15-64 to the total population (POP). As indicator of education, the study applies logarithm of primary education (PEDU), while urbanisation is measured by urban population growth (URP), and the consumer price index (2005 prices) denoted by INF serves as indicator of inflation. Table 1 provides a description of the data.

Table 1. Description of variables for the study				
Variable	Definition	Average	Std. dev.	Expected sign
CRIME	Logarithm of number of crimes recorded by polices	13.53	1.53	(Dep. variable)
GDPG	The growth rate of per capita gross domestic product	2.90	1.93	-
POP	The rate of the population aged 15-64 to the total population	67.11	1.46	+
PEDU	The logarithm of primary education	13.65	1.25	-
URP	Urban population growth	0.85	0.64	+
INF	Consumer price index with 2005 fixed prices	2.72	1.57	+

Definition of neighbourhood will be obtained by applying a Critical Value Neighbourhood (CVN) criterion defined by distances. Specifically, if the distance d_{ij} between two regions i and

j is between a certain critical threshold value d^* , then the two regions are assumed to be neighbours, and the corresponding element w_{ij} of the weight matrix W_N is set to one, while it is set to zero otherwise. For the present study, the threshold value d^* is set to the minimum distance required to ensure that each location has at least one neighbour.

6. Results

The estimation results pertaining to spatial panel data model are given in Table 2. According to the Hausman test, which is used for deciding whether the fixed or the random effect spatial lag model (1) versus (2) should be used, the fixed effects model is convenient for the current situation. According to the similar Hausman statistics for the fixed or random effect spatial error models (3) versus (4), the fixed effect spatial lag model turns out to be superior. For the fixed effect specifications (1) versus (3), the LM statistics may be applied as indication of which type of spatial dependence should apply, It turns out that the spatial lag model is the most convenient for the present data since LM_{ρ}^* is more significant than LM_{λ}^* for the raw as well as the robust versions of the tests. Thus, according to the specification tests, the most convenient specification appears to be the spatial lag fixed effect model (1).

Generally, the signs of all the coefficients of the explanatory variables seem to comply with the theoretical expectations. Thus, the impact of education on crime seems to be negative throughout, so that it might be inferred that uneducated individuals have a significant potential for committing crime. Hence, it might be asserted that crime rates might be reduced placing more emphasis on educating individuals. This supports the claim of Lochner and Moretti (2004), where

it was further shown that increased education expenditures are less costly compared to rehabilitation of individuals involved in crime.

Table 2: The Estimation Results of Spatial Panel Models

Variable	Spatial Lag Models Estimation		Spatial Error Models Estimation	
	(1) Spatial fixed effects model	(2) Spatial random effect model	(3) Spatial fixed effects model	(4) Spatial random effect model
Intercept		6.481* (2.189)		10.556* (4.114)
GDPG	-0.011* (-2.898)	-0.010* (-2.440)	-0.013* (-3.094)	-0.012* (-2.609)
POP	0.048* (3.267)	0.053* (3.296)	0.033* (2.343)	0.042* (2.696)
PEDU	-0.288* (-2.035)	-0.051 (-0.361)	-0.258** (-1.855)	-0.051 (-0.362)
URP	0.048* (1.975)	0.046** (1.734)	0.044** (1.895)	0.040 (1.577)
INF	0.002* (2.041)	0.003* (2.589)	0.005* (3.802)	0.006* (3.829)
ρ	0.335* (3.511)	0.276* (2.711)		
λ			0.364* (3.572)	0.359* (3.255)
<i>LM</i> Tests	$LM_{\rho} = 14.076$ [0.000]		$LM_{\lambda} = 10.989$ [0.001]	
Robust <i>LM</i> Tests	$LM_{\rho}^* = 3.650$ [0.056]		$LM_{\lambda}^* = 0.563$ [0.453]	
LR Test	417.343 [0.000]	263.970 [0.000]	416.551 [0.000]	267.073 [0.000]
Hausman Tests		115.740 [0.000]		54.601 [0.000]

Values in parentheses are t-statistics and values in brackets parentheses are p-values. Also “*”, indicates parameters are significant at 5% and “**” indicates parameters are significant at 10%.

Furthermore, crime rates increase with increasing inflation rates. However, while the coefficient is significant and in accordance with theory, a relatively low effect was determined. Turning to

per capita GDP, the sign of the effect is significantly negative thus supporting the theoretical claim that low economic welfare would increase crime rates.

The coefficients pertaining to urbanization rate and population aged 15-64 are significantly positive as theoretically expected. Thus, it can be asserted that growing urban population is systematically related to problems leading to increased criminal activity, and that an increase in the employment capacity may also be listed among factors that potentially increase crime rates.

7. Conclusion

Crime leads to fear and anxiety in society and disturbs social order and harmony. Therefore, authorities aim at eliminating crime which adversely affects society, both physically and economically. In order to eliminate crime the reasons of crime must be well determined. The present study contributes by examining significance of factors commonly accepted to affect crime rates in EU-15 countries by using spatial panel data methods. A spatial correlation of crime rates among the EU-15 countries is shown to be in play. It is shown that economic capacity and education affect crime negatively while factors such as inflation rate, employment capacity and urban population have positive effects. Regarding the effects of these factors, the present study obtains results comparable to those from former studies, whereby the robustness of these are confirmed.

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