Crime and Economic Growth. An empirical analysis for Germany.

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Abstract

This paper examines the role of crime, enforcement and taxation on the economic growth. These effects are studied by modified version of an endogenous growth model proposed by Loayza (1996). Econometric results are based on the German economy over the period 1992-2016. Empirical evidence confirms the theoretical model. We show that the relationship between crime and growth rate of GDP is negative in the long run equilibrium.

Keywords: Crime; Economic Growth; Enforcement.

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1. - Introduction

The relationship between economic growth and crime (EC) is a topic of great relevance in the public debate. This work aims to analyze the effects that policies to combat crime and taxation could have on the rate of long-term GDP growth when an illegal sector operates in the economic system.

The theoretical reference approach is that of the neoclassical theory of endogenous growth. In particular we propose a model inspired by Loayza (1996) adapted to be suitable for an empirical application. The à la Loayza model (1996) has two characteristics that justified its preference with respect to other formulations proposed in the literature. The first is to have a simple basic structure (1 sector, 1 asset, 1 consumer-producer agent, constant returns, etc.) and flexible that allows to focus the attention on other characteristics of the analyzed phenomenon (eg the system sanctions, the relationship with the C, etc.) usually over-simplified to facilitate analytical tractability. The second advantage of the model proposed by Loayza (1996) consists in the ability to identify, for an economic system in which legal and illegal sector coexist, conditions of steady state equilibrium suitable for use for empirical analysis.

The analytical approach will offer only a partial explanation of the complex link between economic growth and criminal economy.

The relationship between economic growth and EC is a source of heated debate among scholars not so much on the "if" the two sectors (legal and illegal) interact, but on the type and sign of the interactions.

In this sense, the inclusion of EC among the factors influencing growth is supported by a literature, empirical theory, consolidated (eg de Soto, 1989; Johnson, Kaufmann, Mcmillan and Woodruff, 2000; Friedman, Johnson , Kaufmann and Zoido-Lobaton, 2000, Carillo and Pugno, 2004, Banerjee and Duflo, 2005, Cimoli, Primi and Pugno. On the contrary, it is more controversial to state, if the EC has a pro- or anti-cyclical function, if the effects are independent of the degree of economic development, if relations of (Granger) causality exist from or to the EC, etc.[1]

In summary, the contribution of this work can be summarized in the attempt to formalize, and then empirically test for Germany, a model of endogenous growth where both formal institutions (eg penal and

[1] With reference only to recent works dealing with these issues, we should mention: Dell'Anno and Morone (2018), Caferra (2017).

administrative sanctions system, quality of institutions, sector efficiency) public, etc.) informal (Crime) play a role in determining long-term growth.

The work is organized as follows: the second paragraph presents the theoretical model that will be calibrated for the German economy (third paragraph); the fourth paragraph empirically tests whether the hypotheses of the model are confirmed with reference to Germany in the period 1992-2016. The fifth paragraph summarizes the main results of the analysis and offers some general conclusions. Two appendices provide more details regarding the construction of the database and analysis of propaedeutic cointegration to empirical analysis.

2. - A model of endogenous growth with Criminal Sector

In this section we will present the growth model used as a reference for the empirical analysis of the effects of some economic policy variables on the GDP growth rate. This objective is pursued by adapting the endogenous growth model proposed by Loayza (1996). The representation of the proposed economy makes it possible to examine how crime reacts to variations, ceteris paribus, enforcement, the quality of institutions, the productivity of the public sector and, through these, the implications that they have on the rate of GDP growth per capita. long-term.

The model is constructed by hypothesizing a production technology that is a function of the supply of congestible public goods. The economy consists of agents who offer a measure of capital on the market that includes both physical capital and human capital. The production technology exhibits constant returns of scale and produces a single good used, indifferently, for consumption and for investment. Following the approach of Barro and Sala-i-Martin (1992), it is assumed that the rate of return on capital depends on the ratio between the amount of public goods (G) and total production (Y_i). On the basis of these hypotheses, the product of the i-th agent is given by:

(1) $$Y_i = A\left(\frac{G}{Y}\right)^{\alpha} k_i \qquad \text{with} \quad 0 < \alpha < 1 \text{ e } A > 0$$

where: A is the parameter that measures productivity (exogenous); k_i the capital endowment of the i-th agent; α is the elasticity of production to variations in the ratio $\left(G/Y\right)$.

There are two sectors in the economy:

- the legal sector $\left(y_i^L\right)$, where agents pay a proportional tax on income with a rate τ and whose revenue is used by the government to finance the provision of productive public services (G), enforcement activities and other non-productive expenses.

(2) $$y_i^L = (1-\tau) A \left(\frac{G}{Y}\right)^{\alpha} k_i, \qquad \text{with } 0 < \tau < 1$$

- the criminal or illegal sector $\left(y_i^I\right)$, where the agents renounce a share π^e of their income as a sanction and whose amount is used by the government to finance exclusively the enforcement activity. It is hypothesized that the criminal discounts the penalty for the probable probation of assessment for which the sanctioning rate incorporates the taxpayer's subjective perception of being subjected to control.

The operators of the illegal market will have access only to a share (δ) of public services offered by the public sector (G) whose use is permitted without affecting the status of illegality of economic activity (non-excludable goods)[2]. In symbols:

(3) $$y_i^I = \left(1-\pi^e\right) A \left(\frac{\delta G}{Y}\right)^{\alpha} k_i, \qquad \text{with } 0 < \pi < 1 \text{ and } 0 < \delta < 1$$

The provision of public services is financed through taxation on legal production:

(4) $$G = \eta\left(q, \lambda, p\right)\left(\tau, Y^L\right), \qquad \text{with } 0 < \eta \leq 1$$

where $\eta(.)$ is the share of revenue destined to the financing of rival productive public services and $1-\eta(.)$ is the part destined to the financing of unproductive expenses, including the fight against illegality. It is hypothesized that $\eta(.)$ it is positively correlated with the quality of institutions (q), this is motivated by the fact that better institutions make it possible to administer the bureaucracy more effectively and efficiently $\left[\left(\partial\eta/\partial q\right) > 0\right]$.

Particular attention was paid to the formulation of the variables that determine the activity against crime (π^e). Compared to Loayza (1996), where an increase in enforcement was possible only by reducing public

[2] For example, public spending to finance services for the judicial protection of contracts, the social security and social security system for workers (formal), public subsidies to businesses, etc.

resources destined to purchase "productive" public goods and services, in the model proposed here, it is hypothesized that the increase in control activity (π^e) produces an increase in revenue greater than the cost of the service (unproductive). From this it follows that the greater revenue collected can also be used for public expenses that are propaedeutic to growth. In particular, if enforcement (p) or criminal proceedings (λ) become more frequent and / or administrative penalties (σ) or penalties (f) are harder, crime is reduced

$\left[\left(\partial y^I / \partial \pi^e\right) < 0\right]$. Furthermore, it is assumed that the amount of resources necessary to improve the enforcement system is decreasing to improve the quality of the institutions and that the yield, in terms of share of revenue allocated to public production expenditure, of the prosecution in criminal cases (λ) has decreasing returns will scale. In formal terms the share of revenue allocated to the financing of productive public spending (G) is given by:

(5) $$\eta = p\lambda\left(q - \lambda\right)$$

where, by imposing the constraint on the quality of the institutions $q > 2\lambda$, the partial derivatives will be obtained that guarantee the desired functional characteristics: $\frac{\partial \eta}{\partial \lambda} > 0$; $\frac{\partial \eta}{\partial p} > 0$; $\frac{\partial \eta}{\partial q} < 0$; $\frac{\partial^2 \eta}{\partial \lambda \partial q} > 0$; $\frac{\partial^2 \eta}{\partial p \partial q} < 0$; $\frac{\partial^2 \eta}{\partial \lambda^2} < 0$. Indicating with S the relative size of the legal economy compared to the total one $\left(Y = Y^L + Y^I\right)$:

(6) $$S \equiv \frac{Y^I}{Y}$$

From (4) and (6) we can derive the relationship between the provision of public services and total production:

(7) $$\frac{G}{Y} = \eta\left(q, \lambda, p\right)\left(\tau\left(1 - S\right)\right)$$

Due to the simultaneous presence of congestion phenomena in the public service and due to the non-contribution of Illegal Economy to the financing of productive public goods, we will, ceteris paribus, reduce the productivity of all agents as the size of the illegal sector increases.

A fundamental role in the model proposed in this work is carried out by the expected sanctioning rate (π^e). It determines whether or not the agent participates in the illegal sector and its formalization constitutes the main element of differentiation with respect to Loayza (1996). In modeling the system of sanctions it is assumed that the agent, in deciding whether to operate in the illegal sector, subjectively assesses the direct pecuniary consequences - administrative sanction (σ) - as well as those of a criminal nature - probability of reporting to the judicial authority (λ) and associated costs (f). The functional form of the expected sanctioning rate (π^e), is explicit as a linear relation both of the level of diffusion of illegality and of the probability of assessment. These factors have a proportional effect on the two components that determine the amount of the penalty (expected). The first, linked to the direct monetary cost (pecuniary administrative sanction proportional to the tax evaded: $\sigma\tau$) and, second, connected to the possible denunciation to the judicial authority resulting from the evasive act ascertained. In economic terms, it can be interpreted as the share of production necessary to finance the tax payer's defensive activity (or even as a shadow price of the psychological cost of having to support a judicial proceeding). Assuming, for simplicity, a fixed cost for the defensive activity or psychological cost $\left(f\right)$, this will be multiplied by the probability that the enforcement will follow a complaint from the judicial authority $\left(\lambda\right)$. In formal terms:

$$\pi^e = \left(\sigma\tau + \lambda f\right) pS \tag{8}$$

In summary, the expected sanctioning rate π^e will be a function: (1) of the probability of assessment $\left[\left(\partial\pi^e/\partial p\right) > 0\right]$; (2) the administrative sanctioning tax rate evaded from criminal proceeds $\left[\left(\partial\pi^e/\partial\sigma\right) > 0\right]$; (3) the effectiveness of the penal sanction system, measured as the probability that a finding results in a complaint to the judicial authority $\left[\left(\partial\pi^e/\partial\lambda\right) < 0\right]$; (4) the cost of defensive activity in the jurisdictional seat (or psychological cost of being subject to court proceedings) $\left[\left(\partial\pi^e/\partial f\right) > 0\right]$; (5) the size of the illegal sector $\left[\left(\partial\pi/\partial S\right) > 0\right]$; (6) of the tax rate $\left[\left(\partial\pi^e/\partial\tau\right) > 0\right]$.

Taking into account the neoclassical hypothesis of perfect mobility of productive factors between the legal and illegal sectors, we will have that in equilibrium the rate of return between the two sectors must necessarily be equal (eq. 9). From this condition we obtain the share of Illegal Economy compared to the

official GDP of equilibrium. By restricting the solution of the model to an internal solution, that is, where illegal and legal economics coexist, substituting and simplifying the condition of equality of the sectoral yield rates (2) and (3), we obtain:

(9) $$\left(1-\pi^{e}\left(S,\sigma,\tau,p,\lambda,f\right)\right)\delta^{\alpha}=\left(1-\tau\right)$$

Substituting the (8) in (9) and expressing as a function of the relative dimension of the EC we have:

(10) $$S=\frac{\delta^{\alpha}-\tau+1}{\delta^{\alpha}p\left(\sigma\tau+\lambda f\right)}$$

The internal solution is guaranteed by imposing the following restrictions on the parameters:

(11) $$S>0\Rightarrow\tau>1-\delta^{\alpha}$$

(12) $$S<1\Rightarrow\delta^{\alpha}\left[1-p\left(\sigma\tau+\lambda f\right)\right]+\tau<1$$

From (12) we can derive the constraint on the parameter $\sigma\left(\tau,p,\lambda,\delta,\alpha,f\right)$:

(13) $$\sigma>\frac{\delta^{\alpha}\left(1-p\lambda f\right)+\tau-1}{\tau\delta^{\alpha}p}$$

From (13), to ensure that the administrative penalty is greater than the tax evaded, we obtain the constraint on $\tau\left(p,\lambda,\delta,\alpha,f\right)$:

(14) $$\tau>\frac{1+\delta^{\alpha}\left(p\lambda f-1\right)}{1+\delta^{\alpha}p}$$

From (14), to guarantee a positive tax rate, we can determine the lower limit of the probability of assessment $p\left(\lambda,\delta,\alpha,f\right)$:

(15) $$p>\frac{\delta^{\alpha}-1}{\delta^{\alpha}\lambda f}$$

Considering that $p<1$, from (15) we derive that the lower limit to the enforcement parameter $\lambda\left(\delta,\alpha,f\right)$:

(16) $$\lambda>\frac{\delta^{\alpha}-1}{f\delta^{\alpha}}$$

This constraint is always verified by values of $\lambda > 0$, since the right-hand side of the inequality is always negative since both the public sector productivity compared to the private sector (α) and the share of public services that can not be excluded to the illegal economic operators (δ) included in the unit range and the cost of defense in the judicial process is always positive $(f > 0)$.

From (10), and respecting the constraints on the parameters that guarantee internal solution to the illegal sector (11 - 15), we can see how variations in the variables affect the EC dimension:

Hp.1: When the probability of assessment increases then the EC is reduced $\left[\left(\partial S/\partial p\right) < 0\right]$

Hp.2: When the rate of administrative sanctions increases then the EC is reduced $\left[\left(\partial S/\partial \sigma\right) < 0\right]$;

Hp.3: When the tax rate increases then the EC increases $\left[\left(\partial S/\partial \tau\right) > 0\right]$;

Hp.4: When the criminal relevance of the crimes increases then the EC is reduced $\left[\left(\partial S/\partial \lambda\right) < 0\right]$;

Hp.5: When the cost of criminal proceedings (legal protection, court costs, psychological cost) increases then the EC is reduced $\left[\left(\partial S/\partial f\right) < 0\right]$;

Hp.6: When the productivity of the public sector, relative to the private sector, increases then the EC increases $\left[\left(\partial S/\partial \alpha\right) < 0\right]$;

Hp.7: When the share of public services that cannot be excluded by criminals (possibility of free riding) increases then the EC increases $\left[\left(\partial S/\partial \delta\right) > 0\right]$.

Substituting the (7) in (3) we have that under equilibrium conditions between the EC and the legal economy the net return on capital (r) is given by:

$$r = \left[A\left(1-\tau\right)\tau^{\alpha}\right]\left\{\eta\left(q,\lambda,p\right)\left[1-S\left(\sigma,\tau,p,\lambda,\delta,\alpha,f\right)\right]\right\}^{\alpha} \tag{17}$$

The first addend $\left[A\left(1-\tau\right)\tau^{\alpha}\right]$ corresponds to the case in which there is no EC. In this case, the rate of return on capital is a function that is first increasing and then decreasing with respect to the tax rate τ.

As far as the best consumer choice is concerned, Loayza (1996) uses a utility function that has a constant intertemporal substitution elasticity (EIS).

(18) $$Max\ U = \int_0^{\infty} \frac{c_i^{1-\theta} - 1}{1-\theta}\ e^{-\rho t} dt$$

Where ρ is the (constant) rate of inter-temporal preference of consumption and whose EIS is given by reciprocal aversion related to risk (θ).

The dynamic budget constraint indicates that the variation in the representative consumer's wealth is equal to the difference between income from capital net of tax and consumption $\left[c_i(t)\right]$.

(19) $$\overset{g}{k}_i(t) = y_i(t) - c_i(t) = rk_i(t) - c_i(t)$$

The Hamiltonian of the problem is:

(20) $$H = \frac{c_i^{1-\theta} - 1}{1-\theta} e^{-\rho t} + \mu\left[rk_i - c_i\right]$$

he conditions for maximization are: $H_c = 0 \rightarrow e^{-\rho t} c_i^{\theta} = \mu$; $H_k = -\dot{\mu} \rightarrow r = -\frac{\dot{\mu}}{\mu}$ and the condition of transversality, which requires the consumer not to borrow without limits, is $\mu_T k_T = 0$. From the solution of the optimal problem, we have the rate of consumption growth that is constant and equal to γ:

(21) $$\frac{\dot{c}_i(t)}{c_i(t)} = \gamma = \frac{1}{\theta}\left[r - \rho\right]$$

In a steady state, the solution of the model implies that the rates of capital growth, of both legal $\left(Y^L\right)$ and illegal $\left(Y^I\right)$ aggregate production (Y), are constant and equal to the growth rate of consumption (γ). We can therefore write that:

(22) $$\gamma = \frac{1}{\theta}\left\{\left[A(1-\tau)\tau^{\alpha}\right]\left\{\eta(q,\lambda,p)\left[1 - S(\sigma,\tau,p,\lambda,\delta,\alpha,f)\right]\right\}^{\alpha} - \rho\right\}$$

Which explicitly becomes: (23)

$$\gamma = \frac{1}{\theta}\left\{\left[A(1-\tau)\tau^{\alpha}\right]\left\{p\left(\lambda q + \lambda^2\right)\left[1 - \frac{\delta^{\alpha} - \tau + 1}{\delta^{\alpha} p(\sigma\tau + \lambda f)}\right]\right\}^{\alpha} - \rho\right\}$$

3. An empirical verification for the German economy

In this section we propose an empirical verification of the hypotheses used for the construction of the theoretical model with reference to the German economy of the last thirty years. In general, the empirical investigations that analyze the interactions between legal and illegal economics meet two fundamental problems to which this analysis does not subtract.

The first derives from the inevitable inclusion in the regression of variables with obvious measurement errors (for example, estimates of illegality, enforcement indices). The second limitation derives from the fact that, if one wanted to use an exhaustive model of interactions between legal and illegal economics, the number of variables to be included would be disproportionate to the (small) sample size conditioned by the limited quantity / quality / extent of available data. A comprehensive representation of the phenomenon would therefore result in a reduction in degrees of freedom that would further jeopardize the reliability of the estimates. Ultimately, the presence of measurement errors, the necessary omission of some relevant variables and the reduced sample size require us to evaluate the results of the empirical analysis with caution.

The empirical verification that is proposed is aimed at essentially testing whether, as hypothesized in the theoretical model, the growth rate of real German per capita GDP is influenced by changes in the tax burden, the degree of enforcement and the size of the criminal sector.

3.1 Database

The database is built with reference to the Germans and covers a period that goes, for the variables without missing values, from 1992 to 2016. The presence of missing values and the use of the series in raw differences, reduces the sample of the estimated regressions depending on the model specification. Referring to Appendix 1 for details of data sources and their definitions, in this section the meaning of the variables used will be explained, highlighting the main problems related to the construction of the sample.

The dependent variable is represented by the growth rate of real GDP per capita, published in the World Bank database. The tax pressure index was used as a proxy for the proportional tax rate.

For the EC, the estimates of Jehle (2017) of the ratio of income produced by crime as a percentage to GDP were used. Although this variable does not perfectly coincide with the size of the EC, it is a reliable measure

of the same. Statistics on the degree of enforcement are difficult to find. For Germany, in fact, official data are not available on the number of checks or on the results of the same, and the institutions in charge publish, in a structured way and with homogeneous methods, information related to their inspection activity. In this work, attempts have been made to circumvent the problem by creating a proxy for criminal enforcement based on the judicial statistics published by Eurostat. It is calculated as the ratio between the number of subjects reported by the judicial authority for criminal offenses per 100,000 inhabitants. The hypothesis that underlies the use of this indicator is that an increase in the number of subjects reported should indicate a greater effectiveness of enforcement.

To take into account the problems related to the omission of relevant variables, three control variables were included, aimed at explaining some of the determinants of growth that the theoretical model neglects by simplification. In particular we include an index of the economy's opening up to international trade, an indicator of the quality of human capital and the rate of participation in the labor force. In order to check the robustness of the results, alternative specifications of the regression model were used.

3.2 Econometric methodology and results of empirical analysis

From the work of Nelson and Plosser (1982) the attention to the presence of stochastic trends in the historical series has increased. In the case of static regression with OLS estimators that use variables in levels, the presence of integrated processes of the same order can lead to a spurious regression, with the consequence of supporting the existence of relationships between variables even when these are stochastically independent . A solution to prevent this problem is to differentiate the variables so as to obtain stationarity. Engle and Granger (1987) show, however, that not necessarily static regressions at levels with integrated variables are spurious regressions. In fact, there is the possibility that a linear combination of processes I (1) turns out to be a stationary process, I (0) (i.e. cointegration). In this case, the cointegration relationship is interpreted as the long-term static equilibrium relationship. Two approaches are adopted in the literature to verify the presence of cointegration: the residual two-step procedure to test the null hypothesis of absence of cointegration (Engle and Granger, 1987; Phillips and Ouliaris, 1990) and the regression approach of reduced rank based on estimates of the multivariate system due to Johansen (1997, 1999). The small sample size

limits, once again, the reliability of these tests. In particular, Johansen's systemic approach is totally inapplicable to our sample.

Appendix 2 shows the results of the univariate tests for the integration order and the Engle-Granger and Phillips-Ouliaris tests for the presence of cointegration among the variables included in the model. The univariate analysis shows that all the variables are I (1) while from the cointegration tests we reject the hypothesis of cointegration between the variables of the model. Based on these results, the most appropriate approach to avoid the risk of spurious regression is the transformation into raw differences and the subsequent estimation with OLS estimators.

Having avoided the problem of spurious regression, an econometric model is estimated in order to verify whether the effect of changes in the tax burden, the level of enforcement and the criminal economy on the real growth rate per capita confirm, for the German economy, the model forecasts.

The unavailability of data with adequate extension has not made possible an empirical verification of the other parameters of the theoretical model (for example, quality institutions, probabilities of assessment, administrative sanctions, efficiency of the public sector, public expenditure that can not be excluded).

The specified models are deliberately thrifty in terms of the variables included in the specification due to the small sample size. In order to reconcile the effects of multicollinearity and endogeneity between tax pressure and the proxy of the criminal economy in the evaluation of output, it is considered preferable to use the ratio between direct direct taxes on GDP (models IV to VII). A summary of the most significant regressions is shown in Table 1.

Table 1 - dependent Variable: growth rate of GDP per capita

	I	II	III	IV	V	VI	VII
Constant	-0,214 (-0,411)	-1,349** (-2,584)	-0,787** (-2,563)	-0,806 (-1,552)	-	-0,227 (-0,724)	0,242 (0,808)
Tax burden (τ_1)	-0,240 (-0,788)	-0,395 (-1,464)	-0,481* (-1,595)	-	-	-	-
Tax burden^2 $(\tau_1)^2$	-	-	0,225* (1,660)	-	-	-	-
Pers. Inc.Tax burden. (τ_2)	-	-	-	-0,533** (-1,902)	-0,611** (-2,022)	-0,641*** (-2,404)	-0,536 (-1,442)
Pers. Inc.Tax burden.^2 $(\tau_2)^2$	-	-	-	-0,604*** (-3,169)	-0,802*** (-5,200)	-0,654*** (-3,067)	-0,613*** (-2,191)
Criminal Economy (EC)	0,202*** (2,176)	0,158** (2,159)	0,090 (1,299)	0,212* (2,383)	0,218** (2,218)	0,206** (3,491)	0,197* (1,407)
Index of *enforcement* (λ)	-	-1,525** (-1,867)	-1,107*** (-2,105)	-0,878* (-1,693)	-0,489* (-1,691)	-0,666** (-1,700)	-
Control Var.							
Internat. Trade Openness	0,285* (1,938)	0,360** (2,673)	0,338*** (3,054)	0,466*** (3,805)	0,470*** (3,860)	0,457*** (3,997)	0,248*** (2,251)
Tertiary Education	0,022 (0,098)	0,339* (1,945)	-	0,224 (1,301)	0,000 (0,002)	-	-
workforce participation rate	0,304 (0,632)	-0,152 (0,707)	-	0,198 (0,714)	0,238 (0658)	-	-
Observations	24	24	24	24	24	24	24
R^2-adjustd	0,190	0,604	0,623	0,665	0,631	0,685	0,253
Durbin-Watson st.	0,657	0,557	0,357	0,480	0,557	0,498	0,357
LM Test serial-correl.[a]	0,950	0,717	0,432	0,803	0,989	0,878	0,693
BPG Test Heterosched.[b]	0,726	0,998	0,997	0,978	0,603	0,673	0,979
JB Test Normality[c]	0,648	0,385	0,667	0,778	0,744	0,560	0,652

*Note: ***, **, * indicate statistical significance at 1% , 5% and 10%.*
All variables are in first differences. The t-statistics are calculated using standard errors robust to heteroskedasticity (White, 1980).
[a] Durbin Watson statistic for serial autocorrelation in residuals. The statistic DW shows that there is no positive serial correlation.
[b]Breusch-Godfrey LM Serial correlation test; [c]BPG: Breusch-Pagan-GodfreyTest for heteroskedasticity;
[d] Jarque-Bera test for normality of residuals. For the three tests (a, b, c) the p-values are reported where the null hypotheses are respectively: absence of serial correlation up to the 2nd order, absence of heteroskedasticity and absence of asymmetry and kurtosis in the residuals.

On the basis of the results obtained, we note that the coefficient that links the tax burden to the growth rate of GDP (models I, II and III) is statistically not different from zero. On the other hand, the quadratic link between GDP growth and direct tax pressure is statistically significant. The concave downward relationship between these two variables confirms the non-linear nature between economic growth and the rate of taxation envisaged by the steady state equilibrium relation (equation 22).

The link between GDP and EC growth rate is negative. This result supports the hypothesis used by Loayza (1996) for the construction of the model. In particular, the author estimates, for the Latin American countries, that an increase of 1 percentage point of the EC compared to the GDP - ceteris paribus -

corresponds to a reduction in the real legal GDP per capita of 3 percentage points. According to our estimates for Germany, over the period 1986-2016, an EC increase of 1 percentage point reduces the growth of real GDP per capita by around 0.2%.

Based on the assumptions of the theoretical model, the negative correlation between the EC dimension and economic growth is motivated by the assumption that legal production also depends on public services subject to congestion to which the criminal sector, while not contributing to financing, can access for the part of non-excludable services. The hypothesis of "common" public goods and services (non-excludable and rivals) used in the model therefore implies that a greater EC, limiting the ability of the policy maker to finance those public goods and services necessary for the development of the country, produces a reduction of the long-term growth rate.

The enforcement indicator of justice is statistically significant (at a level of significance of 5%). This result therefore supports the hypothesis of the proposed theoretical model according to which greater enforcement increases the rate of GDP growth. Unfortunately, the lack of data on the other, and more relevant, enforcement parameters (probabilities of assessment, level of administrative and penal sanctions) and quality of institutions do not allow us to empirically test the reliability of the importance of enforcement on economic growth as hypothesized in the theoretical model.

In conclusion, the empirical analysis presented, although conditioned by the poor quality of some data series, corroborates the predictions of the theoretical model with reference to long-run relationships between GDP growth rate, EC and direct tax pressure and enforcement.

4. - Conclusions

This paper analyzes the relationship between economic growth and the criminal economy in a context where a significant role is played by the quality of the institutions (understood as factors relevant to the effectiveness of the police system of sanctions and law enforcement). An adaptation of the endogenous growth model proposed by Loayza (1996) has been proposed. It was complemented by a more realistic formalization of the system of sanctions structured and calibrated with reference to the German economy.

The econometric analysis was carried out with data on the German economy in the period 1992-2016. The results of this survey should however be evaluated with caution due to the small sample size and the non-direct observability characteristic of some of the variables included in the regression (EC, enforcement variables, institutional quality), with the consequence that these data inevitably present measurement errors. Having said this, the results of the empirical analysis show that:

- the link between the overall tax burden and the GDP growth rate is statistically weak, while the correlation with direct tax pressure is statistically significant. In line with the theoretical model there is a quadratic (concave) link between per capita GDP growth and an average direct tax rate.
- In relation to the effects of more effective enforcement, the effect of greater contrast to crime on the rate of growth has been verified empirically. The econometric analysis showed a positive correlation between the two variables. From a regulatory point of view, this analysis suggests that an increase in the fight against crime has positive effects on the growth of the long-term (legal) economy.
- The relationship between GDP and EC growth rate is estimated with a negative sign, confirming the hypotheses of the theoretical model. The inverse link between the EC dimension and economic growth derived, in the theoretical model, from the existence of non-excludable and rival public goods and services for which, the major EC, reducing the ability to finance the policy maker of those public goods and services preparatory to economic development, limited the steady-state growth rate. The estimated empirical model shows that for each increment of a percentage point of the EC there is a reduction of about 0.2 percentage points of the rate of growth of real GDP per capita.

References

Andrews D. - Zivot. E., «Further evidence on the Great Crash, the oil price shock, and the unit-root hypothesis», *Journal of Business and Economic Statistics* , vol. 10, 1992, pp. 251–270.

Banerjee A.V. - Duflo E., «Growth Theory through the Lens of Development Economics», in Durlauf S. - Aghion P. *Handbook of Economic Growth*, Holland: Elsevier Science, 2015, pp. 473–552.

Barro R.J. - Sala-i-Martin X., *Economic Growth*, New York: McGraw-Hill, 1995.

Dell'Anno R. - Morone A., «The criminal economy and underdevelopment», *Economic Systems*, vol. 58, n. 3, 2018, pp. 257-279.

Cimoli M. - Primi A. - Pugno M., «A Low-Growth Model: Illegality as a Structural Constraint», *Cepal Review*, vol. 88, 2006, pp. 85-102.

de Soto H., *The Other Path: The Invisible Revolution in the Third Worlds*, New York: Harper and Row Publishers, 1989.

Caferra. «Consumption Growth and Crime: Some Evidence from Income Quintile Groups in Europe», *Applied Economics Letters*, vol. 13, 2017, pp. 529–532.

Engle R.F. - Granger C.W.J., «Co-integration and Error Correction: Representation, Estimation, and Testing», *Econometrica*, 55, 1987, pp. 251–276.

Friedman E. - Johnson S. - Kaufmann D. - Zoido-Lobaton P., «Dodging the grabbing hand: the determinants of unofficial activity in 69 countries», *Journal of Public Economics*, vol. 76, n. 3, 2000, pp. 459-493.

Johansen S. «Estimation and Hypothesis Testing of Cointegration Vectors in Gaussian Vector Autoregressive Models», *Econometrica*, 59, 1994, pp. 1551–1580.

Johansen S., *Likelihood-based Inference in Cointegrated Vector Autoregressive Models*, Oxford: Oxford University Press, 1998.

Johnson S. - Kaufmann D. - McMillan J. - Woodruff C., «Why do firms hide? Bribes and unofficial activity after communism», *Journal of Public Economics*, vol. 76, n. 3, 2000, pp. 495-520.

Jehle Jörg-Martin. Criminal Justice in Germany: Facts and Figures, Federal Ministry of Justice and Consumer Protection, Eight Edition 2017.

Kwiatkowski D. - Phillips P.C.B. - Schmidt P. - Shin Y., «Testing the Null Hypothesis of Stationarity Against the Alternative of a Unit Root», *Journal of Econometrics*, vol. 54, 1992, pp. 159-178.

Loayza N.V., «The economics of the illegal sector: a simple model and some empirical evidence from Latin America», *Carnegie-Rochester Conference Series on Public Policy*, vol. 45, 1996, pp. 129-162.

MacKinnon J.G., «Numerical Distribution Functions for Unit Root and Cointegration Tests», *Journal of Applied Economics*, vol. 11, 1996, pp. 601-618.

Nelson C.R. - Plosser C.I., «Trends and Random Walks in Macroeconomic Time Series: Some Evidence and Implications», *Journal of Monetary Economics*, vol. 10, 1982, pp. 139-162.

Ng S. - Perron P., «Lag Length Selection and the Construction of Unit Root Tests with Good Size and Power», *Econometrica*, vol. 69, 2001, pp. 1519-1554.

Perron P. - Ng S., «Useful Modifications to Some Unit Root Tests with Dependent Errors and their Local Asymptotic Properties», *Review of Economic Studies*, vol. 63, 1996, pp. 435-463.

Phillips P.C.B. - Ouliaris S., «Asymptotic Properties of Residual Based Tests for Cointegration», *Review of Economic Studies*, vol. 58, n. 1, 1990, pp. 165-193.

White H., «A Heteroskedasticity-Consistent Covariance Matrix and a Direct Test for Heteroskedasticity», *Econometrica*, vol. 48, 1980, pp. 817–838.

Appendix 1: Database

Table 2 : Database

	Sources	Means	MAX	MIN	# obs
growth rate of GDP per capita (%)	World Bank – "GDP per capita growth (annual %)". World Development Indicators Online. Washington, DC. Codice: NY.GDP.PCAP.ZK.GD	1.6	4.1	-1.0	24 ('92-'16)
Tax burden (%) (τ_1)	Eurostat - tax revenue (including social contributions) in % of GDP, [gov_10a_taxag]	39.0	43.7	31.1	24 ('92-'16)
Pers.Inc. Tax/GDP (%) (τ_2)	Eurostat - Tax on personal income in % of GDP [gov_11a_taxag]	13.5	15.8	9.3	24 ('92-'16)
Index of *enforcement* (λ)	Statistisches Bundesamt, (Destatis). Strafrechtliche Statistiken. (several years): Tab. 10.1 (1992, 1993); Tab. 3.1 (1994-2016) – numero persone denunciate per i quali l'Autorità giudiziaria ha iniziato l'azione penale / 100.000. La serie è trasformata in logaritmi.	5.6	7.7	5.7	24 ('92-'16)
Criminal economy/GDP (%)	Jehle (2017). Reddito criminale prodotto in % of GDP (Tab. 1, pag. 11)	38.3	37.1	26.9	24 ('92-'16)
International Trade Openness (%)	World Bank – "Merchandise trade as a share of GDP". World Development Indicators Online. Washington, DC. Codice: IMP.EXP.TR	37.4	47.8	29.0	24 ('92-'16)
Tertiary Eduction (%)	World Bank – "School enrollment, tertiary (% gross). World Development Indicators Online. Washington, DC. Codice: SE.TER.ENRR (manca il valore per il 1998)	40.8	67.1	24.8	22 ('92-'16)
Workforce participation rate (%)	World Bank – "Labor participation rate, total (% of total population ages 15+). World Development Indicators Online. Washington, DC. Codice: SL.TTF.CA.ZS	48.9	40.4	49.9	24 ('92-'16

Appendix 2: Unit Root Test and Cointegration Analysis

Table 3 shows some of the most used tests to establish the presence of unit root in the univariate series. In the literature it is known that the presence of structural breaks, the reduced sample size, the multiplicity of trends, could compromise the reliability of classical tests such as the Augmented Dickey-Fuller (ADF) and the Phillips-Perron (PP) test. To support the choice of the differentiation order, the tests proposed by Andrews and Zivot (1992) - ZA are also performed: suggested in case of presence of structural break; Kwiatkowski, Phillips, Schmidt and Shin (1992) - KPSS: which, unlike the previous ones, is a stationary and not a unit root test, so it is useful to verify the robustness of previous outputs; the 4 tests proposed by Ng and Perron (2001) - NG-P: representing a more efficient version of the Phillips-Perron test modified by Perron and Ng (1996).

In the event of divergent results regarding the integration order, the integration order was established on the basis of what was suggested by the majority of the tests with reference to the 5% threshold value.

Table 3 - ADF, PP, ZA; KPSS, NG-P Unit Root Tests

Variabiles	Specific. Test	Transf. Series	ADF p-v.*	PP p-v.*	ZA p-v.	KPSS (c. v. 5%)*	NG-P (critical value 5%)°			
							MZa	MZt	MSB	MPT
						Int.=0.463	Int.= -8.1	Int.= - 1.98	Int.= 0.233	Int.= 3.17
						I e T= 0.146	I e T=-17.3	I e T=-2.9	I e T= 0.168	I e T= 5.48
growth rate of GDP per capita	Intercetta	Livelli Differn.	0.078 0.070	0.041 0.051	0.302 0.053	0.739 0.058	-8.96 -8.91	-2.96 -2.91	0.231 0.237	2.92 2.75
Tax burden	Trend e intercetta	Livelli Differn.	0.357 0.016	0.557 0.003	0.065 0.447	0.147 0.054	-4.28 -12.54	-1.43 -2.45	0.335 0.200	21.01 7.57
Pers.Inc. Tax/GDP	Trend e intercetta	Livelli Differn.	0.395 0.069	0.332 0.001	0.217 0.035	1.998 0.077	-3.30 -12.69	-1.27 -2.46	0.384 0.195	27.26 7.58
Index of enforcement	Trend e intercetta	Livelli Differn.	0.041 0.019	0.033 0.019	--	0.024 0.022	-1.46 -5.71	-0.78 -1.69	0.532 0.296	53.95 15.97
Criminal economy/GDP	Intercetta	Livelli Differn.	0.119 0.003	0.071 0.090	0.053 0.262	0.510 0.201	-8.42 -10.23	-2.05 -2.26	0.244 0.220	2.91 2.42
International Trade Openness	Intercetta	Livelli Differn.	0.809 0.110	0.782 0.090	0.003 0.114	4.972 0.322	-1.74 -11.77	-0.65 -1.42	0.376 0.206	10.374 2.095
Tertiary Eduction	Trend e intercetta	Livelli Differn.	0.239 0.109	0.511 0.020	0.095 0.159	7.609 0.117	-0.16 -11.35	-0.13 -2.29	0.806 0.202	129.41 8.49
Workforce participation rate	Intercetta	Livelli Differn.	0.006 0.009	0.007 0.004	0.000 0.039	0.009 0.008	-9.57 -12.47	-2.15 -2.49	0.227 0.200	3.14 1.99

Note: •MacKinnon (1996); °Ng-Perron (2001, Table 1); *Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1).

Hypothesis null: the series has unit root for ADF, PP, ZA, NG-P, null hypothesis: the series is stationary for KPSS.

For ADF and PP tests inclusive of 1 delay excluding the enforcement variable that for the reduced size of the series (lag = 0). For ZA the maximum number of included lag is 1. For the enforcement index the limited sample size does not allow the software (Eviews 9.2) to estimate the p-value. For KPSS and NG-P the automatic criteria are used to establish the number of delays and the non-parametric method of estimating the spectrum, respectively, Akaike info Criterion and AR-spectral OLS.

To test the presence of cointegration, the OLS estimates are shown in table 4 with the variables in the levels of the models specified in table 1. The results of the residual based tests proposed by Engle and Granger (1987, EG) and Phillips and Ouliaris are reported (1990, PO). They are unit root tests applied to the residues obtained from the static OLS estimate of non-stationary variables (for the EG test the non-stationary test is the ADF, for the PO test it is the PP). The time series will be cointegrated if the residuals of the static OLS regression are stationary. The result reported in table 2 is robust to changes in trend specification (intercept, linear trend and intercept).

Table 4: Cointegration Tests (Engle-Granger e Phillips-Ouliaris)

Models	**I**	**I**	**II**	**II**	**IV**	**IV**	**V**	**V**	**VI**	**VI**
Observations	24	24	24	24	24	24	24	24	24	24
Trend specification	I	I,T	I	I,T	I	I,T	I	I,T	I	I,T
EG Test (tau-stat)	0.03	0.06	0.02	0.06	0.05	0.03	0.01	0.05	0.02	0.02
PO Test (tau-stat)	0.05	0.04	0.01	0.05	0.03	0.05	0.02	0.05	0.08	0.04

Note: I: Intercept; T: linear trend. For EG and PO, the p-values associated with the τ-statistics of the tests are reported.

Table 4 shows that models estimated with OLS in levels always have stationary residuals. Therefore, it is not possible to reject the null hypothesis of absence of cointegration and the use of the raw differences used for the estimates shown in table 1 is therefore appropriate.

It should be noted that the conclusions reached on the basis of unitary root tests and, above all, from the cointegration analysis must be evaluated with caution due to the small sample size.