Economics Working Paper Series

2018/001

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This Version: January 19, 2018

Abstract

This paper presents a macroeconomic model with crime, human capital, and three taxation policies (consumption, labour, and capital income taxes). In an extension, we endogenize the probability of escaping punishment to depend on government expenditure on public security/police. The model is solved analytically and numerically to derive propositions, which are then verified empirically using cross-country data. Compared to the literature, we find a much higher threshold probability. Above the threshold, the equilibrium crime rate is positively related to the escape probability. In addition, above this threshold level, a rise in capital income tax or a decline in labour income tax would lead to a higher equilibrium crime rate, if the taxes are modelled using marginal tax rates. There also appears to be empirical supports where the equilibrium human capital level depends positively on consumption tax. Lastly, when the probability is endogenized, there also exists a threshold level for the spending on public security/police, above which consumption tax and capital income tax have positive effects on the equilibrium level of human capital.

JEL Classification Numbers: H20; H59; K42; O41

Keywords: Apprehension risk; Crime; Human Capital; Police Spending; Taxation.

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1 Introduction

Ever since the contribution of Becker (1968), most contributions to the economic literature on crime focus upon the incentive to commit crime as a response to the expected return to crime, where the latter depends on the degree of enforcement or the probability of punishment. Notable studies include Imrohoroglu et al. (2004, 2006), Engelhardt et al. (2008), and Neanidis and Papadopoulou (2013), all of whom emphasize the importance of the punishment probability upon the crime rate. Indeed, from Ehrlich (1973) to the more recent studies of Corman and Mocan (2000), Evans and Owens (2007), Lin (2009), Draca et al. (2011), and Harbaugh et al. (2013), a robust inverse relationship between deterrence measures and crime have been established. Nevertheless, recent controversies surrounding police funding cut in the UK raise an often neglected issue in the economics of crime: how the different tax policy instruments would differ in their implications on the crime rate, especially in an economy with human capital considerations.

This paper contributes to the literature by presenting a dynamic general equilibrium model with crime, human capital, and three different tax policies (labour income, capital income, and consumption taxes). Further, in an extension, we endogenize the punishment probability—usually treated as exogenous—to depend on the government expenditure on public security/police. The model is solved analytically and numerically to derive propositions, which are then tested empirically using cross-country data. Notably, consistent with relevant literature, we establish the existence of a threshold probability of escaping punishment above which the equilibrium crime rate is positively related to the probability, though the threshold found is much higher in the presence of human capital and tax considerations. In addition, we also show empirically that, above this threshold level, a rise in capital income tax or a decline in labour income tax leads to a higher equlibrium crime rate, if the taxes are modelled using marginal tax rates instead of government revenue-calculated average tax rates. Empirical support is also found for a positive relationship between the equilibrium human capital level and consumption tax. Lastly, when the expenditure on police is introduced, there is additional empirical evidence of a threshold level for the spending on public order and security, above which consumption tax and capital income tax have positive effects on the equilibrium level of human capital. If long-term public spending on public order and security is above the threshold level, there is an economic rationale to fund this spending using consumption and capital income taxes.

In general, recent macroeconomic models of crime have taken two directions. Based on Pissarides type of search considerations, studies such as Engelhardt et al. (2008), Engelhardt (2010), Long and Polito (2014), and Braun (2017) focus on the effects of unemployment frictions on crime. These have a predominant labour market policy focus. On the other hand, with the alternative direction, crime is explored in the context of multi-sectorial growth models. Of note is the overlapping generations model of Neanidis and Papadopoulou (2013), which examines the link between crime and fertility via a tradeoff between criminal activity and child-rearing. Mocan et al. (2005) incorporate elements of human capital in allowing individuals to choose between legal and illegal activity. Our paper is closest to these two studies, in that we introduce a time allocation tradeoff similar to Neanidis and Papadopoulou (2013), while examining the interactions of crime and human capital as in Mocan et al. (2005). The novel aspects in our approach are that, in addition to the introduction of a Glomm-Ravikumar (1997, 2001) type of human capital elements and the different tax considerations, compared to the former, we model crime as an optimal choice of time allocation by individuals, therefore possessing a direct tradeoff to market work. We also recognize time allocation as an issue that necessitates a model with shorter time horizon than an overlapping generations framework. Unlike these studies, our paper also introduces a direct tradeoff (through time allocation) between criminal activity and effective (human capital adjusted) market activity. An asymmetric structure is introduced in that crime is specified as not depending on human capital, which generally fits the nature of non-organized crime such as theft/robbery better.

On the other hand, in comparison to the standard human capital literature, another novel contribution is that, we apply a slightly different approach in modelling human capital and growth: human capital is modelled as a time-bounded productivity factor instead of a conventional Lucas-type disembodied approach, where human capital stock is allowed to grow without bounds. As such, endogenous growth is generated using a standard AK-framework. This means in the steady state, output grows at the same constant rate as the physical capital stock, rather than the stock of human capital.[1,2] Unlike in a human capital-driven growth setting, this allows us to avoid having crime—a direct trade-off to effective market hours—to be unambigiously bad to economic growth. Indeed, as shown below in the empirical section, this modelling choice is consistent with the empirical evidence.

In terms of the literature on different tax structures, since Leibfritz et al. (1997) documented a gradual shift over time from capital to labour income taxes, and subsequently consumption taxes, empirical evidence predominantly favours consumption tax as the most growth-friendly taxation policy. For instance, based on an error correction model (with human capital) applied to OECD economies, Arnold (2008) finds both personal and corporate income taxes to be associated with lower growth but not consumption taxes. Gemmell et al. (2014) improve on these studies by introducing marginal tax rates and compare them to the relatively macro-based average tax rates in a small open economy context. However, by design, a shortcoming these empirical papers generally have is limited theoretical grounding, and therefore do not allow for the analytical understanding of the relationships between policy variables. We set out to examine the implications of different taxes in this model with crime and human capital, focusing primarily on the

[1] The level of human capital determines effective market hours used in production. However, its positive economic effect is partly mitigated in this model in that, it also determines the actual realized hours that trade off those of leisure hours.

[2] Our model is therefore in the same spirit as studies with embodied human capital modelling approach, such as Tanaka and Iwaisako (2009), Agénor and Canuto (2017). These studies with overlapping generations model bind/constraint human capital to a distribution of productivity among the agents, while we provide the counterpart in a hourly context.

long-term relationships.

The rest of the paper is structured as follows. Section 2 presents the model. The model is solved for its equilibrium in Section 3. Section 4 presents comparative statics of equilibrium crime rate and human capital with respect to the set of policy arrangements, with the analytically derived propositions also examined numerically. Section 5 considers the extension of endogenizing punishment probability to government spending on public security/police. It is then followed by Section 6, which empirically evaluates the derived propositions using cross-country panel growth regressions. Section 7 concludes the paper.

2 The Model

Preferences: The economy is populated by a large number of infinitely lived, overlapping generations individuals. Each individual maximizes expected discounted utility,

$$U_t = E_t \sum_{t=0}^{\infty} \beta^t u(c_t, l_t, h_{t+1}), \tag{1}$$

where β denotes the subjective discount factor, c_t, l_t, and h_{t+1} refer to consumption, leisure, and the next-period level of human capital[3].

Each individual is endowed with Γ hours of time in each period t. At the beginning of each period, an individual chooses the time to be allocated to both market work (n_t) and criminal activity (θ_t). However, the actual realized hours for the former at the end of the period t is effective in nature because it is productivity-(human capital-)adjusted. The disutility associated with the tradeoff from leisure therefore comes from the effective human capital-adjusted market work ($h_t n_t$), the time spent in commiting crime (θ_t), and a fixed exogenous amount of time in other non-economic productive activity (ε). This

[3] In a finite generational overlapping generations (OLG) setting, such as a typical setting commonly seen in the literature where individuals live for three periods and each individual is assumed to have one child in each period, h_{t+1} can be interpreted as the human capital of the children.

means $l_t = \Gamma - h_t n_t - \theta_t - \varepsilon$, $h_t n_t \leq \Gamma$. This bounded (by time) specification essentially gives a per-hour context to the level of human capital, in which it is measured as a per-hour productivity factor that is only relevant to market work, taken as given by the individuals.[4]

We believe this specification improves on more commonly used alternatives, such as $\Gamma = l_t + n_t + \theta_t + \varepsilon$, or $\Gamma = l_t + n_t + \theta_t + h_t + \varepsilon$. The former assumes human capital activity to be completely independent of leisure and market work considerations by households, even though it is customary for a human capital-based model to assume complementarity in the production side. On the other hand, the shortcoming of the latter is that, while it incorporates training as a time allocation choice, it assumes no complementarity between human capital and market work by treating them as a direct trade-off. Our specification accounts for some disutility from human capital activity (via its influence on the actual effective working hours) yet allows for the modelling of a direct trade-off between the productivity-adjusted market hours and the non-human capital related criminal activity (theft/robbery in the context of this model), a key feature dropped in studies such as Neanidis and Papadopoulou (2013). By implication of the time-bounded specification, this also partly mitigates a well-known shortcoming associated with standard Uzawa-Lucas models, in which human capital is disembodied and allowed to grow infinitely without bounds despite individuals having physical limitations.

Following Neanidis and Papadopoulou (2013), we assume that all individuals allocate time to criminal activity, and that they can be both perpetrators and victims of crime—an agent homogeneity and non-mutually exclusive specification that is in consistent with Mocan et al. (2005) and Mauro and Carmeci (2007). Similarly, in line with studies such as Imrohoroğlu et al. (2004, 2006), the income from criminal activity, interpretable as

[4] The interpretation to our specification is that, while individuals choose their time allocation to market works (n_t), it is the disutility from effective working hours that has to be accounted for in its trade-off with leisure. For example, a researcher or manager contracted for 8 hours of daily work is often required to work more in effective terms, compared to a routine-task administrator who is contracted for the same hours.

either theft or robbery in this context, x_t, is specified as

$$x_t = \theta_t(1-\tau)h_t n_t w_t. \tag{2}$$

In addition to legal and illegal income, individuals accumulate assets in the form of government bonds (b_t) and physical capital (k_t), while also spend z_t amount of resources in education[5]. In each period, an individual's budget constraint is given by

$$\begin{aligned} & (1-\pi_v)(1-\tau_n)h_t n_t w_t + \pi x_t + (1+r_t^B)b_{t-1} + (r_t^k - \delta)(1-\tau_k)k_{t-1} + k_{t-1} \\ = \; & (1+\tau_c)c_t + b_t + k_t + z_t, \end{aligned} \tag{3}$$

where π_v is the (equal) probability of becoming a victim of crime[6], $\pi \in (0,1)$ the probability of escaping punishment, w_t the real wage rate, τ_n labour income tax rate, τ_c consumption tax rate, τ_k capital income tax rate, r_t^k the market interest rate, r_t^B the returns on governmental bonds, and δ the depreciation rate. Moreover, it is assumed that, when an individual is caught and punished (with probability $1-\pi$), the illegal income from crime is confiscated by the government.

Individuals maximize their intertemporal utility (1) by choosing c_t, n_t, z_t, θ_t, b_t, and k_t, subject to the budget constraint of (3), yielding the first-order conditions:

$$\beta^{-1}\frac{u_{c,t}}{u_{c,t+1}} = 1 + (r_t^k - \delta)(1-\tau_k), \tag{4}$$

$$\frac{u_{c,t}}{(1+\tau_c)} = u_{h,t}h_{z,t}, \tag{5}$$

$$\frac{u_{n,t}}{u_{\theta,t}} = \frac{(1-\pi_v+\pi\theta_t)(1-\tau_n)}{\pi(1-\tau_n)n_t}. \tag{6}$$

$$r_t^B = (r_t^k - \delta)(1-\tau_k). \tag{7}$$

[5] Again, if the model were to be simplified to having a simple three generational OLG setting instead of a generalized one, this amount is interpretable as parents' investment in children's education.

[6] Similar to Imrohoglu et al. (2004, 2006), we assume that the incidence of crime is random and the criminals do not have the ability to target victims based on their income. For simplicity, it is also assumed that a victimized individual would lost all her/his after-tax wage income.

Human Capital: In consistent with the model specification of studies linking human capital and public spending on education, such as Glomm and Ravikumar (1997, 2001), Blankenau et al. (2007), and Agénor (2011), human capital accumulation depends on private spending on education, efficiency-adjusted public spending on education, as well as the accumulated stock of human capital in the economy, proxied by the average level of human capital in the previous period. Specifically, human capital accumulates in accordance to the function of

$$h_{t+1} = (\chi_E \frac{g_t^E}{Y_t})^{\nu_1} (H_t)^{1-\nu_1-\nu_2} (\frac{z_t}{Y_t})^{\nu_2}, \tag{8}$$

where $\chi_E \in (0,1)$ is an efficiency parameter on government spending, $\nu_1, \nu_2 \geq 0$, and both components of education spending (public, g_t^E, and private, z_t) are denoted as a percentage of the final output level in the economy[7].

Final Output: A continuum of identical firms, indexed by $i \in (0,1)$, produce a nonstorable homogeneous final good using private inputs in the form of private physical capital and effective labour. Assuming a Cobb–Douglas technology, the production function is given by

$$Y_t = (\bar{k}_t)^{\varpi} k_{i,t}^{\alpha} (H_t n_{i,t})^{1-\alpha}, \tag{9}$$

where $k_{i,t}$ is the firm-specific stock of physical capital, $n_{i,t}$ the labour hours, H_t the economy-wide human capital level (same across all firms), and $\bar{k}_t = \int_0^1 k_{i,t} di$ the aggregate private capital stock. There is constant return to scale to production, which is also subject to an Arrow-Romer type of production externalities associated with the aggregate private capital stock.

[7]By virtue of the specification, $h_t n_t \leq \Gamma$, human capital in this model has a per hour context, in that it can be interpreted as some sort of per-hour productivity multiplicative factor. Given that its production function depends on χ_E, g_t^E/Y_t, and z_t/Y_t, all $\in (0,1)$, the boundary condition would hold for all solutions of h.

The first-order conditions of firm i are:

$$w_t = (1-\alpha)\frac{Y_{i,t}}{H_t n_{i,t}},\ r_t^k = \alpha\frac{Y_{i,t}}{k_{i,t}}. \tag{10}$$

Given that $Y_t = \int_0^1 Y_{i,t} di$, and that all firms and workers are identical, in a symmetric equilibrium, $n_{i,t} = n_t$, $k_{i,t} = k_t = \bar{k}_t$. Thus, (10) can be rewritten as

$$w_t = (1-\alpha)\frac{Y_t}{H_t n_t},\ r_t^k = \alpha\frac{Y_t}{k_t}. \tag{11}$$

Aggregate output is expressed as

$$Y_t = (k_t)^{\varpi+\alpha}(H_t n_t)^{1-\alpha}. \tag{12}$$

Following Neanidis and Papadopoulou (2013), to generate endogenous growth, we assume $\alpha = \varpi$. This then allows us to rewrite (12) in the standard AK-form, and express the final-output to private physical capital ratio as

$$\frac{Y_t}{k_t} = (H_t n_t)^{1-\alpha}. \tag{13}$$

Government: Government revenue is obtained by taxing wages, consumption, and capital income at constant rates of τ^n, τ^c, and τ^k respectively. When caught and punished, the illegal income of the individuals is confiscated by the government. Following Davig et al. (2011) and Polito and Wickens (2015), the goverment (i) raises funds by issuing bonds, b_t; (ii) repays the principals (plus interest, r_t^B) from the previous period $t-1$. The government expenditure, g_t, is on education (g_t^E), public security/police (g_t^P), and all other categories (g_t^O). In line with Goulas and Zervoyianni (2015), g_t^P is assumed to be non-economic productive in the benchmark model, though we extend the analysis by endogenizing the probability of escaping punishment, π, to depend negatively on the public spending on public security, g_t^P, in the later section.

The government's budget constraint is given by

$$\begin{aligned} g_t &= g_t^E + g_t^P + g_t^O \qquad (14) \\ &= \tau_c c_t + \tau_n w_t H_t n_t + \tau_k (r_t^k - \delta) k_{t-1} + b_t - (1 + r_t^B) b_{t-1} + (1 - \pi)\theta_t (1 - \tau_n) h_t n_t w_t, \end{aligned}$$

where, in line with studies such as Agénor (2011) and Neanidis and Papadopoulou (2013), each individual component of spending is assumed to be a constant fraction of the total government revenue, as in

$$\begin{aligned} g_t^h &= \upsilon_h [\tau_c c_t + \tau_n w_t H_t n_t + \tau_k (r_t^k - \delta) k_{t-1} + b_t \\ &\quad - (1 + r_t^B) b_{t-1} + (1 - \pi)\theta_t (1 - \tau_n) h_t n_t w_t], \end{aligned} \qquad (15)$$

where υ_h, $h = E, P, O$ are the constant shares of spending for the respective categories, and $\sum \upsilon_h = 1$.

For public debt, we follow Polito and Wickens (2015) and assume a simple debt sustainability rule,

$$\frac{d_t}{Y_t} = \frac{b_t}{Y_t} - (1 + r_t^B) \frac{b_{t-1}}{Y_t}, \qquad (16)$$

where by definition, the net issuance of public bonds equals the sovereign debt-to-GDP ratio of the economy, and $d_t / Y_t \leq 0$.

Closing the Economy: To close the model, the economy-wide resource constraint is given by

$$Y_t = c_t + g_t + k_t - (1 - \delta) k_{t-1}, \qquad (17)$$

where, after substituting in (14), is equivalent to

$$\begin{aligned} Y_t &= (1+\tau_c)c_t + [\tau_n + (1-\pi)\theta_t(1-\tau_n)]w_t H_t n_t \\ &\quad + k_t - [(1-\delta) - \tau_k(r_t^k - \delta)]k_{t-1} + b_t - (1+r_t^B)b_{t-1}. \end{aligned} \tag{18}$$

3 Model Solutions and Equilibrium Conditions

Assuming a log-utility function for (1), as given in Appendix A, the model can be described as

$$\beta^{-1}\frac{c_{t+1}}{c_t} = 1 + (\alpha\frac{Y_t}{k_t} - \delta)(1-\tau_k), \tag{19}$$

$$\frac{Y_t}{k_t} = (\frac{(1-\pi_v) + \pi\theta_t}{\pi})^{1-\alpha}, \tag{20}$$

$$\theta_t = \frac{\Gamma}{2} - \frac{(1-\pi_v)}{2\pi} - \frac{\Phi_1}{2}\frac{c_t}{Y_t} - \frac{\varepsilon}{2}, \tag{21}$$

$$\frac{g_t^E}{Y_t} = v_E \left\{ \begin{array}{c} \frac{\tau_c}{\Phi_1}\left[\Gamma - \frac{1}{\pi} + \frac{\pi_v}{\pi} - \varepsilon\right] + (1-\alpha)\tau_n + \left(\Phi_2 - 2\frac{\tau_c}{\Phi_1}\right)\theta_t \\ + \left[\alpha\tau_k - \tau_k\delta\left(\frac{1-\pi_v}{\pi} + \theta_t\right)^{\alpha-1}\right]\frac{k_{t-1}}{k_t} + \frac{d_t}{Y_t} \end{array} \right\}, \tag{22}$$

$$\begin{aligned} \frac{k_t}{k_{t-1}} &= \left\{[1-\delta(1-\tau_k)]\left[\frac{(1-\pi_v)}{\pi} + \theta_t\right]^{\alpha-1} - \alpha\tau_k\right\} \times \\ &\quad \left\{ \begin{array}{c} (1+\tau_c)(\Phi_1)^{-1}[\Gamma - \frac{(1-\pi_v)}{\pi} - 2\theta_t - \varepsilon] \\ +(1-\alpha)\tau_n - 1 + \left[\frac{(1-\pi_v)}{\pi} + \theta_t\right]^{\alpha-1} + \Phi_2\theta_t + \frac{d_t}{Y_t} \end{array} \right\}^{-1}, \end{aligned} \tag{23}$$

with the growth rate being determined by

$$1+\gamma_t = \frac{H_{t+1}}{H_t} = \frac{\Phi_E(\frac{g_t^E}{Y_t})^{\nu_1}}{(\Phi_1)^{\nu_2}\,(H_t)^{\nu_1+\nu_2}}[\Gamma - \frac{(1-\pi_v)}{\pi} - 2\theta_t - \varepsilon]^{\nu_2}, \tag{24}$$

where $\Phi_1 = \psi(1+\tau_c)[\eta_C\pi(1-\tau_n)(1-\alpha)]^{-1}$, $\Phi_2 = (1-\pi)(1-\alpha)(1-\tau_n)$, $\Phi_E = (\chi_E)^{\nu_1}(\frac{\nu_2\eta_H}{\eta_C}(1+\tau_c))^{\nu_2}$.

To solve the model, we define the following equilibrium conditions:

Definition 1: A *competitive equilibrium* is a sequence of allocations $\{c_t, n_t, z_t, \theta_t\}_{t=0}^{\infty}$, prices $\{w_t, r_t^k, r_t^B\}_{t=0}^{\infty}$, physical capital stock and government bonds $\{k_t, b_t\}_{t=0}^{\infty}$, and human capital$\{h_t\}_{t=0}^{\infty}$ such that, given initial stocks $k_0, b_0,\ h_0 > 0$, a set of policy arrangements $\{\tau_c, \tau_n, \tau_k, \upsilon_E, \upsilon_P, \upsilon_O\}$, and an (escape) punishment probability π, all individuals maximize utility, all firms maximize profits, the government mantains its budget in accordance to its debt sustainability rule, and all markets clear. In addition, individual human capital level must be equal to the economy-wide average level of human capital, so that $h_t = H_t$,$\forall t$.

Definition 2: A *stationary equilibrium* is a competitive equilibrium in which: (i) the choice variables $(c_t, n_t, z_t, \theta_t)$, physical capital (k_t), human capital (h_t), final output (Y_t), and government bonds (b_t) are constant $\forall t$, (ii) rates of return (r_t^k, r_t^B) are constant, and (iii) individual and aggregate behaviour are consistent. In addition, the probability of victimization equals the aggregate crime incidence rate, that is $\pi_v = \frac{\theta_t}{\Gamma}$(see Imrohoroğlu et al., 2004).

In the stationary equilibrium, we also know that $\theta_t = \tilde{\theta}$, $k_t = \tilde{k}$, $\frac{d_t}{Y_t} = (\frac{\tilde{d}}{Y}) = \tilde{r}^B(\frac{\tilde{b}}{Y})$ $\forall t$. As also derived in Appendix A, the stationary equilibrium solution is characterized by the two key equations describing the equilibrium crime rate $(\tilde{\theta})$ and the equilibrium level of human capital $(\tilde{H})$:

$$\begin{aligned} f(\tilde{\theta}) &= (1-\alpha)\tau_n - 1 + \alpha\tau_k + (1+\tau_c)(\Phi_1)^{-1}[(\Gamma - \pi^{-1} - \varepsilon) \qquad (25) \\ &+ \left[\Phi_2 + (1+\tau_c)(\Phi_1)^{-1}((\Gamma\pi)^{-1} - 2)\right]\tilde{\theta} + \delta(1-\tau_k)\left[\pi^{-1} + (1-(\Gamma\pi)^{-1})\tilde{\theta}\right]^{\alpha-1} \\ &+ (1-\tau_k)(\frac{\tilde{b}}{Y})\left\{\delta - \alpha[\pi^{-1} + (1-(\Gamma\pi)^{-1})\tilde{\theta}]^{1-\alpha}\right\} = 0, \quad \text{and} \end{aligned}$$

$$\tilde{H} = (\Phi_E)^{\frac{1}{\nu_1+\nu_2}}(\Phi_1)^{-\frac{\nu_2}{\nu_1+\nu_2}}(\frac{\tilde{g}^E}{\tilde{Y}})^{\frac{\nu_1}{\nu_1+\nu_2}}\left[\Gamma - \frac{1}{\pi} - \varepsilon + \tilde{\theta}[(\Gamma\pi)^{-1} - 2]\right]^{\frac{\nu_2}{\nu_1+\nu_2}}, \quad \text{where} \qquad (26)$$

$$\frac{\tilde{g}^E}{\tilde{Y}} = \upsilon_E \left\{ \begin{array}{c} \frac{\tau_c}{\Phi_1}(\Gamma - \varepsilon - \frac{1}{\pi}) + \frac{\tilde{\theta}}{\Gamma\pi}\frac{\tau_c}{\Phi_1} + (1-\alpha)\tau_n + (\Phi_2 - 2\frac{\tau_c}{\Phi_1})\tilde{\theta} \\ + \left[\alpha\tau_k - \tau_k\delta\left[\frac{1}{\pi} + \tilde{\theta}(1-(\Gamma\pi)^{-1})\right]^{\alpha-1}\right] \\ + \left\{\delta - \alpha[\pi^{-1} + (1-(\Gamma\pi)^{-1})\tilde{\theta}]^{1-\alpha}\right\}(1-\tau_k)\frac{\tilde{b}}{Y} \end{array} \right\}. \qquad (27)$$

Applying the implicit function theorem to (25) and directly differentiating (26) with respect to π and the tax policy parameters, we can examine the effects of the various policy arrangements on the crime incidence ($\tilde{\theta}$) and the level of human capital ($\tilde{H}$) in stationary equilibrium.

4 Crime, Human Capital, and Taxation

The comparative statics of the equilibrium $\tilde{\theta}$ and $\tilde{H}$ with respect to π, τ_c, τ_k, τ_n are derived analytically in Appendix A. For the crime incidence ($\tilde{\theta}$), the implicit function theorem is applied:

$$\frac{\partial\tilde{\theta}}{\partial\pi} = -\frac{f_\pi}{f_\theta}, \frac{\partial\tilde{\theta}}{\partial\tau_c} = -\frac{f_{\tau_c}}{f_\theta}, \frac{\partial\tilde{\theta}}{\partial\tau_n} = -\frac{f_{\tau_n}}{f_\theta}, \frac{\partial\tilde{\theta}}{\partial\tau_k} = -\frac{f_{\tau_k}}{f_\theta}, \text{ where} \tag{28}$$

$$\begin{aligned} f_\theta = & \left[\Phi_2 + (1+\tau_c)(\Phi_1)^{-1}((\Gamma\pi)^{-1} - 2)\right] \\ & +(\alpha-1)\delta(1-\tau_k)[1-(\Gamma\pi)^{-1}][\pi^{-1} + (1-(\Gamma\pi)^{-1})\tilde{\theta}]^{\alpha-2} \\ & +\alpha(\alpha-1)(1-\tau_k)[1-(\Gamma\pi)^{-1}]\frac{\tilde{b}}{Y}[\pi^{-1} + (1-(\Gamma\pi)^{-1})\tilde{\theta}]^{-\alpha}, \end{aligned} \tag{29}$$

$$\begin{aligned} f_\pi = & (1+\tau_c)\left\{\frac{1}{\Phi_1\pi^2} - (\Gamma - \varepsilon - \frac{1}{\pi})\frac{\Phi_{1\pi}}{(\Phi_1)^2}\right\} - \tilde{\theta} \\ & -\tilde{\theta}(1+\tau_c)\left\{\frac{\Phi_{1\pi}}{(\Phi_1)^2}[(\Gamma\pi)^{-1} - 2] + \frac{1}{\Gamma\Phi_1\pi^2}\right\} \\ & +\delta(1-\tau_k)(\alpha-1)(\tilde{H}\tilde{n})^{\alpha-2}\left[\pi^{-2}(\frac{\tilde{\theta}}{\Gamma} - 1)\right] \\ & +\alpha(\alpha-1)(1-\tau_k)(\tilde{H}\tilde{n})^{-\alpha}\left[\pi^{-2}(\frac{\tilde{\theta}}{\Gamma} - 1)\right], \end{aligned} \tag{30}$$

$$\begin{aligned} f_{\tau_n} = & (1-\alpha) - (1+\tau_c)(\Gamma - \varepsilon - \frac{1}{\pi})\frac{\Phi_{1\tau_n}}{(\Phi_1)^2} - \tilde{\theta} \\ & -(1+\tau_c)\tilde{\theta}[(\Gamma\pi)^{-1} - 2]\frac{\Phi_{1\tau_n}}{(\Phi_1)^2}, \end{aligned} \tag{31}$$

$$f_{\tau_k} = \alpha - \frac{\tilde{b}}{Y}(1-\tau_k)\left\{\delta - \alpha[\pi^{-1} + (1-(\Gamma\pi)^{-1})\tilde{\theta}]^{1-\alpha}\right\} - \delta[\pi^{-1} + (1-(\Gamma\pi)^{-1})\tilde{\theta}]^{\alpha-1}, \quad (32)$$

and $f_{\tau_c} = 0$, where $\Phi_{1\pi} < 0$, $\Phi_{1\tau_c} > 0$, and $\Phi_{1\tau_n} > 0$.

Proposition 1: $\partial\tilde{\theta}/\partial\tau_c = 0$. The equilibrium crime rate is independent of the consumption tax.

We know that $1 - (\Gamma\pi)^{-1} > 0$ (since $\Gamma\pi > 1$), and for most combinations of $\Gamma\pi$, $(\Gamma\pi)^{-1} - 2 < 0$ can be established. This means $f_\theta < 0$. Similarly, for $f_{\tau_k} > 0$, for a reasonably small value of δ, it is straightforward to establish that $f_{\tau_k} > 0$, which means $\partial\tilde{\theta}/\partial\tau_k > 0$. However, as seen from the derived expressions, the signs of f_π and f_{τ_n} are generally ambiguous, which therefore require numerical evaluations.

For the equilibrium human capital level ($\tilde{H}$), the following comparative statics are derived in Appendix A:

$$\begin{aligned}\frac{\partial\tilde{H}}{\partial\pi} &= \frac{\tilde{H}\nu_2}{(\nu_1+\nu_2)}\left\{[\pi^{-2}(1-\frac{\tilde{\theta}}{\Gamma})]\left[\Gamma - \frac{1}{\pi} - \varepsilon + \tilde{\theta}[(\Gamma\pi)^{-1}-2]\right]^{-1} - \frac{\Phi_{1\pi}}{\Phi_1}\right\} \\ &+ \frac{\tilde{H}\nu_1 v_E}{(\nu_1+\nu_2)}(\frac{\tilde{g}^E}{\tilde{Y}})^{-1}\left\{\begin{array}{c} \frac{\tau_c}{\Phi_1}[\pi^{-2}(1-\frac{\tilde{\theta}}{\Gamma})] - \frac{\tau_c}{\Phi_1}\frac{\Phi_{1\pi}}{\Phi_1}(\Gamma - \frac{1}{\pi} - \varepsilon + \frac{\tilde{\theta}}{\Gamma\pi}) + \left[2\frac{\tau_c\Phi_{1\pi}}{(\Phi_1)^2} - 1\right]\tilde{\theta} \\ +\delta\tau_k(1-\alpha)[\pi^{-2}(\frac{\tilde{\theta}}{\Gamma}-1)] + \frac{\tilde{b}}{Y}\frac{\alpha(\alpha-1)(1-\tau_k)[\pi^{-2}(\frac{\tilde{\theta}}{\Gamma}-1)]}{[\pi^{-1}+(1-(\Gamma\pi)^{-1})\tilde{\theta}]^{\alpha}} \end{array}\right\},\end{aligned} \quad (33)$$

$$\frac{\partial\tilde{H}}{\partial\tau_c} = \frac{\tilde{H}\nu_1 v_E}{(\nu_1+\nu_2)}(\frac{\tilde{g}^E}{\tilde{Y}})^{-1}\left[\begin{array}{c}\Gamma - \frac{1}{\pi} - \varepsilon \\ +\tilde{\theta}[(\Gamma\pi)^{-1}-2]\end{array}\right][(\Phi_1)(1+\tau_c)]^{-1}, \quad (34)$$

$$\frac{\partial\tilde{H}}{\partial\tau_n} = \frac{-\tilde{H}\nu_2}{(\nu_1+\nu_2)}\frac{\Phi_{1\tau_n}}{\Phi_1} + \frac{\tilde{H}\nu_1 v_E}{(\nu_1+\nu_2)}(\frac{\tilde{g}^E}{\tilde{Y}})^{-1}\left\{(1-\alpha) - \tau_c\left[\begin{array}{c}\Gamma - \frac{1}{\pi} - \varepsilon \\ +\tilde{\theta}[(\Gamma\pi)^{-1}-2]\end{array}\right]\right\}, \quad (35)$$

$$\frac{\partial\tilde{H}}{\partial\tau_k} = \frac{\tilde{H}\nu_1 v_E}{(\nu_1+\nu_2)}(\frac{\tilde{g}^E}{\tilde{Y}})^{-1}\left\langle\begin{array}{c}\left\{\alpha - \delta[\pi^{-1} + (1-(\Gamma\pi)^{-1})\tilde{\theta}]^{\alpha-1}\right\} \\ -(1-\tau_k)\frac{\tilde{b}}{Y}\left\{\delta - \alpha[\pi^{-1} + (1-(\Gamma\pi)^{-1})\tilde{\theta}]^{\alpha-1}\right\}\end{array}\right\rangle, \quad (36)$$

$$\begin{aligned}\frac{\partial\tilde{H}}{\partial\tilde{\theta}} &= \frac{\tilde{H}\nu_2[(\Gamma\pi)^{-1}-2]}{(\nu_1+\nu_2)}\left[\Gamma - \frac{1}{\pi} - \varepsilon + \tilde{\theta}[(\Gamma\pi)^{-1}-2]\right]^{-1} \\ &+ \frac{\tilde{H}\nu_1 v_E}{(\nu_1+\nu_2)}(\frac{\tilde{g}^E}{\tilde{Y}})^{-1}\left\{\begin{array}{c}\frac{\tau_c}{\Phi_1}[(\Gamma\pi)^{-1}-2] + \Phi_2 \\ +\tau_k\delta(1-\alpha)[1-(\Gamma\pi)^{-1}][\pi^{-1} + (1-(\Gamma\pi)^{-1})\tilde{\theta}]^{\alpha-2} \\ +\frac{\alpha(\alpha-1)(1-\tau_k)\frac{\tilde{b}}{Y}[1-(\Gamma\pi)^{-1}]}{[\pi^{-1}+(1-(\Gamma\pi)^{-1})\tilde{\theta}]^{\alpha}}\end{array}\right\},\end{aligned} \quad (37)$$

Analytically, we can establish that $\partial \tilde{H}/\partial \tau_c > 0$ since the terms, $\Gamma - \frac{1}{\pi} - \varepsilon + \tilde{\theta}[(\Gamma\pi)^{-1} - 2]$, in (34) equal to the equlibrium level of leisure, $\tilde{l}$, which is assumed to be non-zero. Likewise, because $\Phi_{1\tau_n} > 0$ and $\tau_c \tilde{l} > 1$, $\partial \tilde{H}/\partial \tau_n < 0$ can also be established analytically. The signs of the remaining partial derivatives cannot be established analytically and are evaluated numerically.

For the numerical evaluations, we parameterize the model as follows. The elasticity of final output with respect to private capital, α, is set at a fairly standard value of 0.3. The two parameters in human capital production function, ν_1 for government spending and ν_2 for household spending, are set at 0.2, which is consistent with the empirical estimate of Blankenau et al. (2007) and parameter values used by Chen (2005) and Agénor (2011). For the tax variables, we use the G7-average in the OECD tax database, and set $\tau_k = 0.282$ (in line with the corporate income tax rate), $\tau_c = 0.126$ (in line with the goods and services tax rate), and $\tau_n = 0.276$ (in line with all-in average personal income tax rate)[8].

For the time allocation, assuming 8 hours of sleep, $\Gamma = 16$. We set the time spent in other non-economic productive activity, $\varepsilon = 2$. For the remaining time spent on effective work, leisure, and crime, the parameterisation is bounded by $(\Gamma - \varepsilon) = \tilde{l} + \tilde{h}\tilde{n} + \tilde{\theta}$, as well as the equilibrium condition, $\tilde{h}\tilde{n} = \pi^{-1} + \tilde{\theta}[1 - (\Gamma\pi)^{-1}]$, $\pi \in (0, 1)$. With $\pi \geq 0.5$ being the usual baseline set in related studies, we set $\pi = 0.6$ to begin with, and then determine simultaneously $\tilde{\theta}$ and $\tilde{h}\tilde{n}$. To simplify matters, we set a normalized value $\tilde{H} = \tilde{h} = 1$. Let victimisation probability be about a quarter, $\tilde{\theta} = 4$ is set, which means $\tilde{h}\tilde{n} = 5.5$ is solved for[9]. In terms of the marginal propensity parameters, $\eta_C = 1.0$ and $\psi = 0.6$ are set in

[8] An alternative measure that is popular in the empirical literature is the use of the average tax rate derived from revenue statistics at the macro level, as in the IMF's Worldwide Government Revenue Database. Indeed, for our empirical examination, in order to have a larger sample of countries, the macro-level tax measures are also used.

[9] We recognize the limitation that the parameterized equilibrium value, $\tilde{\theta}$ and $\tilde{h}\tilde{n}$, have a smaller difference than what we would intuitively assume. However, given the absence of time-use data for criminal activities, both are parameterized to meet the equilibrium conditions of the model solution, given other parameters.

line with annual models with time allocation constraint, such as Imrohoroğlu et al. (2004, 2006) and Polito and Wickens (2015). Finally, in line with the numbers presented in the latter, the depreciation rate, δ, is set at 0.03 while the bond-to-output ratio, $b/Y = 0.8$.

Given the set of benchmark parameter values, $f_\theta = -0.825$, $f_\pi = 1.261$, $f_{\tau_n} = -6.625$, $f_{\tau_k} = 0.816$ are calculated. From (28), this means $\partial\tilde{\theta}/\partial\pi > 0$, $\partial\tilde{\theta}/\partial\tau_c = 0$, $\partial\tilde{\theta}/\partial\tau_n < 0$, and $\partial\tilde{\theta}/\partial\tau_k > 0$. The equilibrium crime rate increases as the probability of escaping punishment increases, the labour income tax rate decreases, and the capital income tax rate increases. For the comparative statics of the equilibrium human capital level ($\tilde{H}$), $\partial\tilde{H}/\partial\pi < 0$, $\partial\tilde{H}/\partial\tau_c > 0$, $\partial\tilde{H}/\partial\tau_n < 0$, $\partial\tilde{H}/\partial\tau_k > 0$, and $\partial\tilde{H}/\partial\tilde{\theta} < 0$. These mean that the equilibrium human capital level is higher, the lower the probability of escaping punishment, the higher the consumption tax, the lower the labour income tax, and the higher the capital income tax rate. Lastly, we have an inverse relationship between the equilibrium crime rate and the equilibrium level of human capital. Indeed, the signs of these comparative statics are stable across the range of most parameter values, save for the probability of escaping punishment, π. For the different values of π, the signs of these comparative statics are summarized in Table 1, the numerical results of which allow us to establish:

Proposition 2: There exists a threshold probability, π^*, above which the equilibrium crime rate, $\tilde{\theta}$, depends positively on the probability of escaping punishment, π.

Proposition 3: Above a threshold probability, π^*, labour income tax, τ_n, and capital income tax, τ_k, have opposite policy effects on the equilibrium crime rate. Specifically, a rise in capital income tax, τ_k, or a decline in labour income tax, τ_n, would lead to a higher equlibrium crime rate.

Proposition 4: There exists a threshold probability, π^*, above which the equilibrium level of human capital depends positively on consumption tax, τ_c, and capital income tax, τ_k, but negatively on the labour income tax, τ_n.

5 Endogenous probability and police spending

A natural extension is to endogenize the probability of escaping punishment, π, so that it depends negatively on government expenditure on public security/police, g_t^P/Y_t. This means $\partial\pi/\partial v_P < 0$. In comparison to (27), the only difference for the specification of g_t^P/Y_t is the constant share of spending, v_P, out of the total public expenditure. To evaluate $\partial\tilde{\theta}/\partial v_P$ is relatively straightforward since $\partial\tilde{\theta}/\partial v_P = (\partial\tilde{\theta}/\partial\pi)(\partial\pi/\partial v_P)$.

Proposition 5: When the probability, π, is endogenous to public spending on public security/police, above a probability threshold π^*, the higher the share of government spending on public security/police is, the lower the equilibrium crime rate.

However, to re-derive all the comparative statics, we would need to first specify a functional form. Suppose $\pi = \pi_0 \left(\frac{\tilde{g}^P}{Y}\right)^{-\kappa}$, where $\pi_0 \in (0,1)$, $\kappa > 0$[10]. The difference from the previous implicit function theorem analysis that yields $-f_\pi/f_\theta$ in (28) is that, the new $\hat{f}_\theta$ and $\hat{f}_\pi$ are now given by

$$\hat{f}_\theta = f_\theta - \kappa\pi_0\pi\left(\frac{\tilde{g}^P}{Y}\right)^{-1} v_P \left\{ \begin{array}{c} \frac{\tau_c}{\Phi_1}[(\Gamma\pi)^{-1} - 2] + \Phi_2 \\ +\tau_k\delta(1-\alpha)[1-(\Gamma\pi)^{-1}][\pi^{-1} + (1-(\Gamma\pi)^{-1})\tilde{\theta}]^{\alpha-2} \\ +\frac{\alpha(\alpha-1)(1-\tau_k)\frac{\tilde{b}}{Y}[1-(\Gamma\pi)^{-1}]}{[\pi^{-1}+(1-(\Gamma\pi)^{-1})\tilde{\theta}]^{\alpha}} \end{array} \right\}$$
$$\times \left\{ \begin{array}{c} (1+\tau_c)\left[\frac{\pi^{-2}}{\Phi_1} - \frac{\Phi_{1\pi}}{(\Phi_1)^2}(\Gamma - \pi^{-1} - \varepsilon)\right] + \Phi_{2\pi}\tilde{\theta} - \tilde{\theta}(1+\tau_c)\left(\frac{\Phi_{1\pi}}{(\Phi_1)^2}[(\Gamma\pi)^{-1} - 2] + \frac{\Phi_1^{-1}}{\Gamma\pi^2}\right) \\ +\frac{(1-\tau_k)(\alpha-1)}{[\pi^{-1}+(1-(\Gamma\pi)^{-1})\tilde{\theta}]}[\frac{1}{\pi^2}(\frac{\tilde{\theta}}{\Gamma} - 1)]\delta + \alpha\frac{\tilde{b}}{Y}\tilde{\theta}^{1-\alpha} \end{array} \right\}, \tag{38}$$

$$\hat{f}_\pi = -f_\pi\kappa\pi_0\pi\left(\frac{\tilde{g}^P}{Y}\right)^{-1} v_P \left\{ \begin{array}{c} \frac{\tau_c}{\Phi_1}[\pi^{-2}(1-\frac{\tilde{\theta}}{\Gamma})] - \frac{\tau_c}{\Phi_1}\frac{\Phi_{1\pi}}{\Phi_1}(\Gamma - \frac{1}{\pi} - \varepsilon + \frac{\tilde{\theta}}{\Gamma\pi}) + \left[2\frac{\tau_c\Phi_{1\pi}}{(\Phi_1)^2} - 1\right]\tilde{\theta} \\ +\delta\tau_k(1-\alpha)[\pi^{-2}(\frac{\tilde{\theta}}{\Gamma} - 1)] + \frac{\tilde{b}}{Y}\frac{\alpha(\alpha-1)(1-\tau_k)[\pi^{-2}(\frac{\tilde{\theta}}{\Gamma}-1)]}{[\pi^{-1}+(1-(\Gamma\pi)^{-1})\tilde{\theta}]^{\alpha}} \end{array} \right\}, \tag{39}$$

where the terms $\tilde{\theta}$ and π inside the $\tilde{g}^P/Y$ expression would also have to be accounted for. Similarly, the new $\hat{f}_{\tau_c}$, $\hat{f}_{\tau_n}$, and $\hat{f}_{\tau_k}$ are derived, where the full analytical expressions are

[10] A more accurate representation would entail specifying an underlying distribution for π and model the transitional probabilities over time. For the task at hand of providing an extension to the comparative static analysis, the simplified form presented serves the purposes.

presented in Appendix A (refer (A49)-(A51)).

Likewise, for the new comparative statics of human capital (partial derivatives with $\hat{H}$), we can express $\partial\hat{H}/\partial\pi$ as

$$\frac{\partial \hat{H}}{\partial \pi} = -\frac{\partial \tilde{H}}{\partial \pi}\kappa\pi_0\pi\left(\frac{\tilde{g}^P}{Y}\right)^{-1} \upsilon_P \left\{ \begin{array}{c} \frac{\tau_c}{\Phi_1}[\pi^{-2}(1-\frac{\tilde{\theta}}{\Gamma})] - \frac{\tau_c}{\Phi_1}\frac{\Phi_{1\pi}}{\Phi_1}(\Gamma - \frac{1}{\pi} - \varepsilon + \frac{\tilde{\theta}}{\Gamma\pi}) \\ + \left[2\frac{\tau_c\Phi_{1\pi}}{(\Phi_1)^2} - 1\right]\tilde{\theta} \\ +\delta\tau_k(1-\alpha)[\pi^{-2}(\frac{\tilde{\theta}}{\Gamma}-1)] + \frac{\tilde{b}}{Y}\frac{\alpha(\alpha-1)(1-\tau_k)[\pi^{-2}(\frac{\tilde{\theta}}{\Gamma}-1)]}{[\pi^{-1}+(1-(\Gamma\pi)^{-1})\tilde{\theta}]^{\alpha}} \end{array} \right\}, \tag{40}$$

where $\partial\tilde{H}/\partial\pi$ is from (33). For the other comparative statics, they are given by

$$\frac{\partial \hat{H}}{\partial \tau_c} = \frac{\partial \tilde{H}}{\partial \tau_c} + \frac{\partial \hat{H}}{\partial \pi}\left[\begin{array}{c} \Gamma - \frac{1}{\pi} - \varepsilon \\ +\tilde{\theta}[(\Gamma\pi)^{-1} - 2] \end{array} \right][(\Phi_1)(1+\tau_c)]^{-1}, \tag{41}$$

$$\frac{\partial \hat{H}}{\partial \tau_n} = \frac{\partial \tilde{H}}{\partial \tau_n} + \frac{\partial \hat{H}}{\partial \pi}\left\{(1-\alpha) - \tau_c\left[\begin{array}{c} \Gamma - \frac{1}{\pi} - \varepsilon \\ +\tilde{\theta}[(\Gamma\pi)^{-1} - 2] \end{array} \right]\right\}, \tag{42}$$

$$\frac{\partial \hat{H}}{\partial \tau_k} = \frac{\partial \tilde{H}}{\partial \tau_k} + \frac{\partial \hat{H}}{\partial \pi}\left\langle \begin{array}{c} \left\{\alpha - \delta[\pi^{-1} + (1-(\Gamma\pi)^{-1})\tilde{\theta}]^{\alpha-1}\right\} \\ -(1-\tau_k)\frac{\tilde{b}}{Y}\left\{\delta - \alpha[\pi^{-1} + (1-(\Gamma\pi)^{-1})\tilde{\theta}]^{\alpha-1}\right\} \end{array} \right\rangle, \tag{43}$$

$$\frac{\partial \hat{H}}{\partial \hat{\theta}} = \frac{\partial \tilde{H}}{\partial \tilde{\theta}} + \frac{\partial \hat{H}}{\partial \pi}\left\{ \begin{array}{c} \frac{\tau_c}{\Phi_1}[(\Gamma\pi)^{-1} - 2] + \Phi_2 \\ +\tau_k\delta(1-\alpha)[1-(\Gamma\pi)^{-1}][\pi^{-1} + (1-(\Gamma\pi)^{-1})\tilde{\theta}]^{\alpha-2} \\ +\frac{\alpha(\alpha-1)(1-\tau_k)\frac{\tilde{b}}{Y}[1-(\Gamma\pi)^{-1}]}{[\pi^{-1}+(1-(\Gamma\pi)^{-1})\tilde{\theta}]^{\alpha}} \end{array} \right\}, \tag{44}$$

respectively, where the relevant partial derivatives are obtained from (34)-(37) and (43).

Based on the same set of parameter values considered in the benchmark analysis, plus setting $\upsilon_P = 0.1$, $\kappa = 0.2$, and $\tilde{g}^P/Y_t = 0.02$ (which allows derivation of π_0 that gives $\pi = 0.6$), we again numerically evaluate the comparative statics, with key results summarized in Table 2. The derived Propositions 2-4 from the benchmark case still largely hold, save for having a slightly different threshold value for initial π. Nevertheless, with the extension, the change in consumption tax has material effect on the equilibrium crime rate, in that

Proposition 6: When the probability, π, is endogenous to government spending on public security/police, above a threshold probability, π^*, the equilibrium crime rate depends negatively on consumption tax.

We can also derive another proposition that links the signs of the comparative static effects to the initial level of government spending on public security/police, based on the numerical evaluations, as follows.

Proposition 7: When the probability, π, is endogenous to government spending on public security/police, there exists a threshold level, $(g^P/Y_t)^*$, above which consumption tax and capital income tax have positive effects on the equilibrium level of human capital.

This proposition essentially implies that, if the long-term public spending on police (as percentage of GDP) is above a certain threshold level, the use of consumption and capital income tax to finance this spending could be warranted as it delivers a higher equilibrium level of human capital.

6 Empirical Analysis

6.1 Empirical set-up

Based on (25) and (26), to test the seven derived propositions empirically, we specify a linearized version of the system for the (θ, H) pairing, although it is worth noting from (25) that the former does not depend on the latter. The empirical forms to be tested are represented by:

$$\begin{aligned} \theta_{jt} &= \alpha_0 + \alpha_1 \pi_{jt} + \alpha_2 \pi_{jt}^2 + \alpha_3 \tau_{n_{jt}} + \alpha_4 \tau_{k_{jt}} + \alpha_5 \tau_{c_{jt}} \\ &\quad + \alpha_6 DebtGDP_{jt} + \sum_{l=1}^{L} \psi_l X_{l,jt} + \epsilon_j + u_{jt}, \end{aligned} \tag{45}$$

$$\begin{aligned} H_{jt} &= \beta_0 + \beta_1 \theta_{jt} + \beta_2 \pi_{jt} + \beta_3 \pi_{jt}^2 + \beta_4 \tau_{n_{jt}} + \beta_5 \tau_{k_{jt}} + \beta_6 \tau_{c_{jt}} \\ &\quad + \beta_7 DebtGDP_{jt} + \beta_8 EdugGDP_{jt} + \sum_{m=1}^{M} \psi_m W_{m,jt} + \iota_j + v_{jt}, \end{aligned} \tag{46}$$

where $j(t)$ is the country (time) index, $i(t)$ refers to the individual observation, $EdugGDP_{jt}$ is public spending on education (as shares of GDP), $DebtGDP_{jt}$ is the sovereign debt-to-GDP ratio, $\{X_{l,jt}\}_{l=1}^{L}$ and $\{W_{m,jt}\}_{m=1}^{M}$ denote the set of control variables commonly used in the literature of crime and human capital. Specifically, $\{X_{l,jt}\}_{l=1}^{L}$ include logarithm of the level of GDP, real GDP growth, urban population share, unemployment rate, and the share of working age population; and $\{W_{m,jt}\}_{m=1}^{M}$include gross secondary enrolment rate, life expectancy, logarithm of total population, and urban population share.[11] ϵ_j and ι_j are the time-invariant country-specific effects, and u_{jt} and v_{jt} are random error terms uncorrelated with the regressors. The square terms of (escape) punishment probability (π_{jt}^2) are included given that most of the derived propositions are subject to a threshold probability, π^*.

For the extension with an endogenized probability of escaping punishment, a simultaneous equation set-up that prioritizes endogeneity of the key variables becomes important. This is especially so when the impacts of crime and human capital on economic growth are also assessed. We therefore estimate an extended system in which two additional equations are added to (45) and (46). These are:

$$\pi_{jt} = \gamma_0 + \gamma_1 PSGDP_{jt} + \gamma_2 PSGDP_{jt}^2 + \sum_{q=1}^{Q} \psi_q Z_{q,jt} + \xi_j + \varepsilon_{jt}, \tag{47}$$

$$g_{jt} = \delta_0 + \delta_1 H_{jt} + \delta_2 H_{jt}^2 + \delta_3 \theta_{jt} + \sum_{r=1}^{R} \psi_r \Psi_{r,jt} + \varpi_j + \varsigma_{jt}, \tag{48}$$

where (47) estimates the probability, π, as a function of government expenditure on public order and safety (percentage of GDP), its square term (to account for the threshold in *Proposition 7*), and $\{Z_{q,jt}\}_{q=1}^{Q}$, a set of demographic variables as controls. (48) models GDP growth rate as a function of the crime rate (θ_{jt}), level of human capital (H_{jt})

[11] See, for instance, Gaviria and Pagés (2002), Neanidis and Papadopoulou (2013), and Goulas and Zervoyianni (2015).

and its square term, and $\{\Psi_{r,jt}\}_{r=1}^{R}$ set of control variables commonly used in growth regressions (investment, trade openness, inflation rate).[12] While not being the main focus, the estimation of the GDP growth equation allows us to verify whether the choice of using a bounded human capital, AK-form specification applied in the theoretical model of this paper (for which then, we would expect δ_1 and δ_2 to be insignificant while the coefficient for physical capital investment will be highly significant) is consistent with the empirical evidence.

6.2 Data, variables, and empirical limitations

We construct an unbalanced dataset containing information on crime, human capital, tax rates, economic growth, government spending variables, and other macroeconomic and demographic variables. While we started off with a full sample across 98 economies and 40-years period of 1976-2015 by extracting the data from the various waves of the *United Nations Survey of Crime Trends and Operations of Criminal Justice Systems* (UN-CTS)[13], the relevant statistics on thefts and robberies are filled with gaps and missing observations. As such, many observations drop out and we are left with an actual sample of 1008 observations across 63 economies and 15-years period of 1991-2005 to be used for the empirical estimation.

For the tax rates variables, the average measures are obtained from the tax revenue statistics of the *International Monetary Fund* (IMF), while marginal tax rates are obtained from the *OECD Tax Statistics* database. For human capital, we use the human capital index in the Penn World Tables 9.0, which is based on Psacharopoulos (1994) and

[12] Given that (45)-(48) are jointly estimated as a system, the four key policy parameters (π, τ_n, τ_k, τ_c) are not included as direct regressors in the equation for GDP growth, as their effects on growth are specified to be indirectly through human capital and crime. The inclusion of the square term for human capital is intended to control for any threshold effect.

[13] Technically, the first wave of the UN-CTS survey was from 1970-75. Nevertheless, many variables of interest, such as the prosecution and conviction statistics by the different category of criminal activities, are not available.

Barro and Lee (2013). The government spending variables, which include expenditure on education, and public order and safety, are obtained from IMF's *Government Finance Statistics* database. The GDP level and growth rates, and the remaining control variables are obtained from the World Bank *World Development Indicators* and the IMF's *World Economic Outlook* database.

To be consistent with the description of crime, θ, in the model, we use both the total recorded theft and robbery rates (per 100,000 population), which also provide means to assess whether differences in the aggression level would affect the estimation results. For the probability of avoiding punishment, π, given the limited data on arrest—only available in the earliest wave of UN-CTS surveys—we use recorded prosecution cases, and supplemented it with recorded convictions for the robustness check. Specifically, π is proxied by one minus the proportion of prosecuted/convicted (of total recorded) cases for the specific category of theft and robbery. For the three tax rate variables, to account for the well-documented shortcoming of average tax rates derived from government revenue data (see Gemmell et al. (2014))[14], we consider both the average tax rates (percent of GDP) and the marginal tax rates. For the former, labour income tax, τ_n, is proxied by personal income tax revenue (percent of GDP), capital income tax, τ_k, by corporate income tax revenue (percent of GDP), and consumption tax, τ_c, by goods and services tax (GST) revenue (percent of GDP). For marginal rates, we use the OECD dataset and therefore have a much smaller sample of economies. The mid-personal income tax rate is used as a proxy for marginal labour income tax, the adjusted statutory corporate income tax rate as a proxy for marginal capital income tax, and the adjusted standard GST tax rate as a proxy for marginal consumption tax. The definition and sources of these and all the other variables used in the empirical analysis, as well as the set of countries, are

[14] Gemmell et al. (2014) argue that, the commonly used average tax rates are derived from macro-, tax revenue data and therefore ought to not have any behavioural implication on the agents defined in any theoretical model. In contrast, marginal tax rates are by definition, micro in nature. The use of marginal tax rates is therefore better suited for economic interpretation.

presented in Appendix B, with the summary statistics presented in Table 3.

In terms of econometric strategy, a common practice in cross-country regressions is to take the fixed effects (FE) estimator for granted, which does not apply in this instance. Indeed, as seen later, for many of the regressions, the Hausman test indicates that the extra orthogonality conditions imposed by a random-effect (RE) estimator are valid. We suspect this to be largely due to the relatively small sample of observations within some of the panel (economies), once the standard growth regression practice of taking 5-year averages (to filter out business cycle effects) is implemented. For instance, in some of the regressions implemented, the average number of observations is as low as 2.3. However, given that all the propositions are derived in the long-run context of steady-state equilibrium, this is a necessary procedure. By implication, the small T problem also prevents us from implementing the standard system-GMM estimator. While the issue of endogeneity (over time) is largely overcome by taking 5-year averages and so partly mitigating the aforementioned shortcomings[15], as a robustness check, we opt to examine both the RE- and FE-estimated results for (45) and (46) because it is the sign rather than the precise value of the estimates in which we are most interested. Further, given the mixed results, based on the superior estimator identified (a RE-estimator is preferred if the Hausman test gives a P-value above 5 percent; a FE-estimator is preferred if the opposite is true), the implied threshold value is calculated for each regression and a further threshold regression with restricted sample is implemented. To account for the endogeneity of human capital, crime rate, and (escape) punishment probability, for the growth regression based on the long-run context of steady-state equilibrium, we implement a three-stage-least-squares (3SLS) procedure, controlling for country and time fixed effects, to jointly estimate the four equations.

[15] The gap between two consecutive observations is $t = 5$ years, which is a sufficient gap to filter out most of the endogeneity through serial correlations, hence making the needs of adding lagged variables as instruments unnecessary.

Overall, the proposed empirical strategy is by design, building in some robustness checks as the estimations are implemented not just by using different econometric methods, but also by using different measures for punishment (prosecution and conviction), tax rates (average versus marginal taxes), and crime (theft and robbery).

6.3 Empirical results

The results for the crime equation, (45) are presented in Tables 4 and 5, and the results for the human capital equation, (46) are presented in Tables 6 and 7. We evaluate **Propositions 1-4**, derived from the benchmark model, primarily on the basis of these results. The 3SLS estimation results for the four-equations, endogenous system (with endogenous punishment probability) are presented in Tables 8 and 9. We evaluate **Propositions 5-7** using these results.

6.3.1 Crime equation

While we have mixed statistical significance, **Proposition 2** is largely confirmed by the results. Specifically, there exists a threshold probability, π^*, above which the equilibrium crime rate, $\tilde{\theta}$, depends positively on the probability of escaping punishment, π. 12 out of 16 of the estimated regressions imply a U-shape ($\hat{\alpha}_1$ negative and $\hat{\alpha}_2$ positive), with threshold values ranging between $0.389 - 0.781$. Indeed, if we were to ignore the convinction data and focus only on the prosecution data, the range of π^* would narrow to $0.609 - 0.641$. These are much higher than the implied threshold values documented in Neanidis and Papadopoulou (2013). This suggests that, if human capital and tax considerations were to be accounted for, and that crime involvement is the outcome of an optimal choice (which is the case with our model), the threshold probability of escaping punishment would have to be much higher for the direct positive relationship with crime to set in. This is intuitively reasonable. The statistical significance of the positive relationship above the threshold π^* is well-established, as all but one of the estimated threshold values in Tables 4 and 5 are significant and positive at the 10 percent level.

In terms of taxes, **Proposition 3** states that, above a threshold probability, π^*, labour income tax, τ_n, and capital income tax, τ_k, have opposite policy effects on the equilibrium crime rate. Thus, a rise in capital income tax, τ_k, or a decline in labour income tax, τ_n, would lead to a higher equlibrium crime rate. While statistical significance remains an issue, we notice significantly different results between the use of average tax rates and the marginal tax rates, à la Gemmell et al. (2014). Based on the estimated results in Tables 4 and 5, for the capital income tax, τ_k, we observe predominantly positive estimates for $\hat{\alpha}_4$ when marginal tax rates are used, while negative estimates are observed when average tax rates are used. Given that our numerical parameterization is based on the marginal corporate tax rate of the G7 economies, and that marginal tax rates tend to be more suitable for behavioural interpretation, the positive effect of marginal τ_k on crime is consistent with Proposition 3, albeit with limited statistical significance. For labour income tax, τ_n, although the estimated signs are mixed, we do generally observe opposite effects of τ_n on crime rate when compared to those for τ_k. Moreover, the estimated coefficients for $\hat{\alpha}_3$ are mainly negative when marginal tax rates are used, which is consistent with the prediction of Proposition 3.

For consumption tax, τ_c, **Proposition 1** states the independence of the equilibrium crime rate from the effects of consumption tax. The proposition was not supported, as the estimated coefficients for $\hat{\alpha}_5$ have a mixture of signs and are mostly statistically insignificant. No consistent patterns are discernable. The may likely reflect inherent difficulties in finding a good empirical proxy that is a pure representation of a direct tax on households' consumption: in practice, the commonly used GST/VAT rates would also apply to intermediate goods and services.

6.3.2 Human capital equation

Proposition 4 concerns the existence of a threshold probability above which the equilibrium level of human capital is positively related to consumption tax, τ_c, and capital income tax, τ_k, but negatively related to the labour income tax, τ_n. Based on the estimated coefficients of $\hat{\beta}_2$ and $\hat{\beta}_3$ in Tables 6 and 7, we observe a threshold effect of π, though statistical significance remains mixed. Further, unlike the crime equation, the regressions with restricted sample above the implied threshold also give a mixture of signs too, hence the results for the relationship between π and human capital are inconclusive.

In regards to the consumption tax, τ_c, there is some empirical support. Most estimated coefficients of $\hat{\beta}_6$ are positive, albeit at poor statistical significance again. However, in the benchmark regression with prosecution data and average tax rates as proxies (see Table 6), we have reasonable statistical significance, with both the regressions with sample above the implied threshold value yield an estimates (0.017 and 0.019) that are significant at the ten percent level. In terms of the estimated coefficients for labour income tax, $\hat{\beta}_4$, contrasting results are again observed between the regressions using average tax rates and those using marginal tax rates. The proposition, $\partial \tilde{H} / \partial \tau_n < 0$, holds when we model τ_n using marginal income tax rates, and all but two of the estimates are statistically significant at the ten percent level. Yet, when the tax revenue data-calculated average tax rate is used, we obtain significant positive estimates. Given that the marginal tax rate provides the more appropriate interpretation, we have a comparatively robust verification. Lastly, results relating to the capital income tax, τ_k, are essentially random and cannot be verified by data.

6.3.3 Endogenous probability and growth

Tables 8 and 9 present the 3SLS-estimated results of the four linearized equations that are consistent with the stationary equilibrium of the model. The findings associated with

Propositions 1-4 largely hold. We therefore focus on evaluating Propositions 5, 6, and 7, which are only applicable when the probability, π, is endogenous to public spending on police (proxied by the government expenditure on public order and security).

First, **Proposition 5** is not directly testable using our empirical form. However, we can indirectly test the proposition by using a combination of the estimates for α_1, α_2 (refer Proposition 2) and γ_1, γ_2. Six of the eight pairs of estimates ($\hat{\alpha}_1$, $\hat{\alpha}_2$) are consistent with Proposition 2, which means we have a U-shape, where above the implied threshold level, the equilibrium crime rate is higher, the higher the probability of escaping punishment is. To be in consistent with Proposition 5, which states a positive relationship between equilibrium crime rate and the spending on police, we need to observe an inverted-U shaped curve between the spending and probability variables. Even though the statistical significance associated with the estimated results using conviction data in Table 9 are very poor, overall, we do have a consistent combination of positive and negative estimates for $\hat{\gamma}_1$ and $\hat{\gamma}_2$ in all the regressions, with good statistical significance for the robbery-data based estimates in Table 8.

Indeed, the estimated threshold for the level of government expenditure on public order and security is in the range $0.133 - 0.333$. This can be narrowed to $0.133 - 0.162$ if we ignore the relatively insignificant estimates using conviction data. The establishment of the threshold level leads us to **Proposition 7**: consumption tax and capital income tax have positive effects on the equilibrium level of human capital when the endogeneity of the (escape) punishment probability is modelled. All but two of the estimated coefficients for $\hat{\beta}_6$ are positive. Again, if we rule out estimates using conviction data (Table 9), we have consistently significant positive estimates for the relationship between consumption tax and the equilibrium level of human capital. In terms of capital income tax, overall statistical significance is an issue again despite a predominantly positive signs for the estimated $\hat{\beta}_5$. Nevertheless, if we were to focus only on the regressions using prosecution and marginal tax rates data, then we have some empirical significance for the positive coefficients, and therefore Proposition 7.

The growth regression of (48) is implemented primarily to investigate our choice in using an AK-framework (instead of Lucas type where output grows at the same constant rate as human capital) is supported by empirical data. Indeed, the estimated coefficients associated with private investment are consistently significant in the growth equation, whereas the effects (both level and threshold) of human capital are neither statistically significant nor consistently positive. As such, our choice of modelling human capital as a time-bounded productivity factor and using an AK-framework in deriving endogenous growth is backed by empirical evidence.

7 Concluding Remarks

The main purpose of this paper is to develop a macroeconomic model with crime, human capital, and various taxation policies. In an extension, we endogenize the (escape) punishment probability—usually treated as exogenous—to depend on government expenditure on public security/police. The addition of taxation and police spending improves upon existing literature on the macroeconomics of crime by allowing an expanded scope of policy analysis. The model is solved analytically and numerically to obtain propositions, which are then tested empirically using cross-country data. The main findings are summarized in the paper and need not be repeated here. Instead, we conclude by reviewing some of the shortcomings and how these might be improved upon.

The relatively small number of observations used for many of the estimated equations prevents the implementation of instrumented econometric approach—using lagged variables—when empirically testing the propositions. As the UN-CTS dataset and the tax databases expand their coverage over time, the representativeness of these estimates would eventually improve as we get to employ more sophisticated econometric techniques. Second, while we have introduced additional fiscal variables (labour income taxes, capital income taxes, consumption taxes, government expenditure on education, government expenditure on police) in this model and therefore has room for much richer policy analysis compared to previous studies in the crime literature, the specification of public debts is largely simplified. This means the implications of public debt dynamics on these policy variables cannot be properly analyzed. Third, the main priority in this paper is on analyzing the stationary equilibrium of the model. As such, we do not examine the dynamics of crime and its implications on the dynamics—be it permanent or temporary—of other variables. Indeed, this issue is examined in much details in Jia and Lim (2018), who develop a dynamic stochastic general equilibrium (DSGE) model of crime with differential human capital in a monetary economy. Given that the present literature on the economic analysis of crime remains largely independent from the financial and monetary sides of the economy, despite the original seminal contribution of Becker (1968) having emphasized criminal involvements being a function of the expected monetary returns, studies examining the interactions of criminal activity and macroeconomic policy management provide potential avenues for future research.

References

Agénor, Pierre-Richard, 2011. Schooling and public capital in a model of endogenous growth. Economica 78, 108-132.

Agénor, Pierre-Richard, Canuto, Otaviano, 2012. Access to finance, product innovation and middle-income traps. Research in Economics 71, 337-355.

Arnold, Jens, 2008. Do tax structures affect aggregate economic growth?: Empirical evidence from a panel of OECD countries. OECD Economics Department Working Paper 643.

Barro, Robert, Jong-Wha, Lee, 2013. A new data set of educational attainment in the world, 1950-2010. Journal of Development Economics 104, 184-198.

Becker, Gary S, 1968. Crime and punishment: An economic approach. Journal of Political Economy 78, 169-217.

Blankenau, William, Simpson, Nicole, Tomljanovich, Marc, 2007. Public education expenditures, taxation, and growth: Linking data to theory. American Economic Review 97, 393-397.

Braun, Christine, 2017. Crime and the minimum wage. Meeting Papers 359, Society for Economic Dynamics.

Chen, Hung-ju, 2005. Educational systems, growth and income distribution: A quantitative analysis. Journal of Development Economics 76, 325-353.

Corman, Hope, Mocan, H. Naci, 2000. A time-series analysis of crime, deterrence, and drug abuse in New York city. American Economic Review 90, 584-604.

Davig, Troy, Leeper, Eric, Walker, Todd, 2011. Inflation and the fiscal limit. European Economic Review 55, 31-47.

Draca Mirko, Machin, Stephen, Witt, Robert, 2011. Panic on the streets of London: Police, crime, and the July 2005 terror attacks. American Economic Review 101, 2157-2181.

Ehrlich, Isaac, 1973. Participation in illegitimate activities: A theoretical and empirical investigation. Journal of Political Economy 81, 521-565.

Engelhardt, Bryan, 2010. The effect of employment frictions on crime. Journal of Labor Economics 28, 677-718.

Engelhardt, Bryan, Rocheteau, Guillaume, Peter, Rupert, 2008. Crime and the labor market: A search model with optimal contracts. Journal of Public Economics 92, 1876-1891.

Gaviria, Alejandro, Pagés, Carmen, 2002. Patterns of crime victimization in Latin American cities. Journal of Development Economics, 67, 181-203.

Gemmell, Norman, Kneller, Richard, Sanz, Ismael, 2014. The growth effects of tax rates in the OECD. Canadian Journal of Economics 47, 1217-1255.

Goulas, Eleftherios, Zervoyianni, Athina, 2015. Economic growth and crime: Is there an asymmetric relationship? Economic Modelling 49, 286-295.

Glomm, Gerhard, Ravikumar, B, 1997. Productive government expenditures and long-run growth. Journal of Economic Dynamics and Control 21, 183-204.

Glomm, Gerhard, Ravikumar, B, 2001. Human capital accumulation and endogenous public expenditures. Canadian Journal of Economics 34, 807-826.

Harbaugh, William, Mocan, Naci, Visser, Michael, 2013. Theft and deterrence. Journal of Labor Research 34, 389-407.

Imrohoroğlu, Ayse, Merlo, Antonio, Peter, Rupert, 2004. What accounts for the decline in crime? International Economic Review 45, 707-729.

Imrohoroğlu, Ayse, Merlo, Antonio, Peter, Rupert, 2006. Understanding the determinants of crime. Journal of Economics and Finance 30, 270-284.

Jia, Pengfei, Lim, King Yoong, 2018. A dynamic model of crime with differential human capital in a monetary economy. Lancaster University Management School, mimeo.

Leibfritz, Willi, Thornton, John, Bibbee, Alexandra, 1997. Taxation and economic performance. OECD Economics Department Working Paper 176.

Lin, Ming-Jen, 2009. More police, less crime: Evidence from US state data. International Review of Law and Economics 29, 73-80.

Long, Iain W, Polito, Vito, 2014. Unemployment, crime and social insurance. Cardiff Economics Working Paper E2014/9, Cardiff University.

Mauro, Luciano, Carmeci, Gaetano, 2007. A poverty trap of crime and unemployment. Review of Development Economics 11, 450-462.

Mocan, H. Naci, Billups Stephen, Overland, Jody, 2005. A dynamic model of differential human capital and criminal activity. Economica 72, 655-681.

Neanidis, Kyriakos, Papadopoulou, Vea, 2013. Crime, fertility, and economic growth: Theory and evidence. Journal of Economic Behavior & Organization 91, 101-121.

Polito, Vito, Wickens, Michael, 2015. Sovereign credit ratings in the European Union: A model-based fiscal analysis. European Economic Review 78, 220-247

Psacharopoulos, George, 1994. Returns to investment in education: A global update. World Development 22, 1325-1343.

Tanaka, Hitoshi, Iwaisako, Tatsuro, 2009. Product cycles, endogenous skill acquisition, and wage inequality. Canadian Journal of Economics 42, 300-331.

Table 1
Summary of the Comparative Static Results: Different Initial Values of π

π	$\partial\tilde{\theta}/\partial\pi$	$\partial\tilde{\theta}/\partial\tau_c$	$\partial\tilde{\theta}/\partial\tau_n$	$\partial\tilde{\theta}/\partial\tau_k$	$\partial\tilde{H}/\partial\pi$	$\partial\tilde{H}/\partial\tau_c$	$\partial\tilde{H}/\partial\tau_n$	$\partial\tilde{H}/\partial\tau_k$	$\partial\tilde{H}/\partial\tilde{\theta}$
0.1	-ve	0	+ve	-ve	-ve	-ve	+ve	+ve	+ve
0.2	-ve	0	+ve	-ve	-ve	+ve	-ve	+ve	+ve
0.3	+ve	0	-ve	+ve	-ve	+ve	-ve	+ve	+ve
0.4	+ve	0	-ve	+ve	-ve	+ve	-ve	+ve	-ve
0.5	+ve	0	-ve	+ve	-ve	+ve	-ve	+ve	-ve
0.6	+ve	0	-ve	+ve	-ve	+ve	-ve	+ve	-ve
0.7	+ve	0	-ve	+ve	-ve	+ve	-ve	+ve	-ve
0.8	+ve	0	-ve	+ve	-ve	+ve	-ve	+ve	-ve
0.9	+ve	0	-ve	+ve	-ve	+ve	-ve	+ve	-ve

Table 2
Endogenous π: Summary of the Comparative Static Results

	$\partial\hat{\theta}/\partial\pi$	$\partial\hat{\theta}/\partial\tau_c$	$\partial\hat{\theta}/\partial\tau_n$	$\partial\hat{\theta}/\partial\tau_k$	$\partial\hat{H}/\partial\pi$	$\partial\hat{H}/\partial\tau_c$	$\partial\hat{H}/\partial\tau_n$	$\partial\hat{H}/\partial\tau_k$	$\partial\hat{H}/\partial\hat{\theta}$
$\tilde{g}^P/Y$									
0.02	+ve	-ve	-ve	+ve	-ve	-ve	-ve	-ve	-ve
0.04	+ve	-ve	-ve	+ve	-ve	+ve	-ve	+ve	-ve
0.06	+ve	-ve	-ve	+ve	-ve	+ve	-ve	+ve	-ve
0.08	+ve	-ve	-ve	+ve	-ve	+ve	-ve	+ve	-ve
0.10	+ve	-ve	-ve	+ve	-ve	+ve	-ve	+ve	-ve
v_P									
0.05	+ve	-ve	-ve	+ve	-ve	+ve	-ve	+ve	-ve
0.10	+ve	-ve	-ve	+ve	-ve	-ve	-ve	-ve	-ve
0.15	+ve	-ve	-ve	+ve	-ve	-ve	-ve	-ve	-ve
0.20	+ve	-ve	-ve	+ve	-ve	-ve	-ve	-ve	-ve

Table 3
Summary Statistics

Variables	Mean	Std Dev.	Min	Max	Obs
Crime rate:					
Theft	1,244.312	1,530.025	0.221	8,772.341	2,100
Robbery	92.354	181.285	0.044	2,141.068	2,124
Punishment probability:					
Prosecution					
Theft	0.738	0.227	0.025	1.000	657
Robbery	0.623	0.248	0.009	1.000	645
Conviction					
Theft	0.821	0.181	0.091	1.000	839
Robbery	0.701	0.232	0.000	0.998	913
Human Capital	2.513	0.636	1.066	3.734	3,211
Average tax rates:					
Personal income tax	5.071	4.676	0.001	27.341	1,765
Corporate income tax	2.901	2.082	0.007	25.506	1,864
Goods & services tax	8.695	3.942	0.034	31.027	2,002
Marginal tax rates:					
Personal income tax	4.939	0.045	0.637	22.545	1,035
Corporate income tax	32.536	10.966	8.500	61.750	1,029
Goods & services tax	17.619	5.213	3.000	27.000	1,030
Gross debt/ GDP	53.263	34.234	0.062	260.964	2,029
Spending on public order & safety	1.501	1.178	0.000	20.258	1,158
Spending on education	4.450	1.516	0.000	10.679	2,032
Gross enrolment rate, secondary	81.146	27.319	2.282	166.808	2,886
Logarithm of output	4.763	1.897	-1.398	9.817	3,448
Urban population	60.532	21.567	3.678	100.000	3,679
Unemployment rate	8.300	5.630	0.200	37.300	2,275
Working-age population	63.282	5.991	47.354	85.872	3,679
Life expectancy	70.734	7.660	43.172	84.278	3,679
Logarithm of total population	2.319	1.771	-1.962	7.222	3,350
Investment	22.923	6.277	2.647	65.560	3,198
Trade	80.975	56.312	8.385	442.620	3,271
Inflation	29.424	293.310	-23.822	11,749.640	3,231

Notes: All variables are based on annual data. A detailed description of the variables are presented in Table B1.

Table 4
Results for Benchmark Model with Exogenous π, Crime Equation
(one-way FE and RE models, plus restricted threshold model)

Prosecution rate as proxy

	Average Tax Rates						Marginal Tax Rates					
	Theft			Robbery			Theft			Robbery		
	RE	FE	Restricted Threshold	RE	FE	Restricted Threshold	RE	FE	Restricted Threshold	RE	FE	Restricted Threshold
Probability of escape, π	-2576.235	-1728.636	**4227.513**	-64.809	-53.551	**227.234**	5057.044	-60237.620	**3680.351**	-134.168	-34.906	**308.108**
	(0.203)	(0.580)	**(0.001)**	(0.291)	(0.244)	**(0.000)**	(0.290)	(0.106)	**(0.056)**	(0.075)	(0.564)	**(0.002)**
Escape probability squared, π^2	3300.782	2303.402		81.606	61.780		-1017.213	40310.160		194.363	42.485	
	(0.061)	(0.353)		(0.149)	(0.196)		(0.799)	(0.099)		(0.044)	(0.591)	
Labour income tax, π_n	188.828	95.539	**202.457**	0.218	4.948	**3.209**	-58.661	81.206	**-63.066**	-0.060	0.151	**0.721**
	(0.000)	(0.589)	**(0.000)**	(0.943)	(0.242)	**(0.449)**	(0.433)	(0.566)	**(0.379)**	(0.970)	(0.923)	**(0.794)**
Capital income tax, π_k	-39.348	-158.805	**-26.477**	-1.786	-1.057	**-22.235**	20.518	29.932	**20.043**	0.263	1.107	**0.075**
	(0.685)	(0.322)	**(0.844)**	(0.488)	(0.700)	**(0.000)**	(0.411)	(0.080)	**(0.421)**	(0.666)	(0.062)	**(0.892)**
Consumption tax, π_c	78.145	148.389	**71.457**	-0.340	-1.079	**-2.941**	116.442	-426.034	**116.556**	-1.379	6.181	**-6.767**
	(0.099)	(0.260)	**(0.244)**	(0.865)	(0.567)	**(0.351)**	(0.059)	(0.369)	**(0.053)**	(0.654)	(0.155)	**(0.271)**
Gross debt-to-GDP ratio	-3.367	-8.985	**-5.352**	-0.055	0.127	**0.757**	-8.025	-23.484	**-7.683**	0.029	0.201	**2.184**
	(0.361)	(0.509)	**(0.241)**	(0.767)	(0.547)	**(0.220)**	(0.494)	(0.426)	**(0.509)**	(0.917)	(0.471)	**(0.000)**
Logarithm of GDP	228.666	1416.796	**229.508**	-0.207	-34.507	**-18.084**	447.515	1380.843	**436.972**	-8.437	-157.736	**-380.984**
	(0.032)	(0.590)	**(0.095)**	(0.983)	(0.467)	**(0.324)**	(0.106)	(0.754)	**(0.093)**	(0.570)	(0.065)	**(0.004)**
Real GDP growth	-499.187	-1744.801	**148.131**	47.469	44.103	**201.796**	-107.479	-2439.176	**-85.631**	4.896	-34.809	**29.782**
	(0.250)	(0.219)	**(0.803)**	(0.071)	(0.138)	**(0.001)**	(0.940)	(0.265)	**(0.953)**	(0.875)	(0.334)	**(0.358)**
Urban population	-2.426	-80.392	**-7.135**	0.926	1.697	**2.340**	50.536	-130.336	**49.812**	-0.064	2.185	**2.750**
	(0.751)	(0.671)	**(0.565)**	(0.344)	(0.399)	**(0.086)**	(0.008)	(0.563)	**(0.008)**	(0.961)	(0.313)	**(0.245)**
Unemployment rate	1.640	67.702	**1.369**	1.482	-0.155	**-0.142**	86.830	153.583	**81.365**	0.285	-2.285	**-13.285**
	(0.947)	(0.476)	**(0.967)**	(0.414)	(0.945)	**(0.969)**	(0.253)	(0.340)	**(0.304)**	(0.881)	(0.402)	**(0.000)**
Working-age population	-27.078	64.643	**-22.118**	-2.409	-0.189	**1.065**	42.950	-144.530	**38.834**	-0.953	14.165	**20.657**
	(0.474)	(0.628)	**(0.689)**	(0.168)	(0.953)	**(0.644)**	(0.733)	(0.705)	**(0.760)**	(0.802)	(0.061)	**(0.013)**
Country Effect	No	Yes	**No**	No	Yes	**No**	No	Yes	**No**	No	Yes	**Yes**
Time Effect	Yes	Yes	**Yes**	Yes	Yes	**Yes**	Yes	Yes	**Yes**	Yes	Yes	**Yes**
Countries/Observations	52/94	52/94	**43/72**	51/97	51/97	**34/56**	27/59	27/59	**27/59**	26/62	26/62	**18/39**
Overall R^2	0.688	0.109	**0.647**	0.151	0.001	**0.015**	0.412	0.004	**0.421**	0.314	0.010	**0.005**
Hausman test (p-value)	0.950			0.116			0.432			0.037		
Threshold value	0.641		**0.641**	0.630		**0.630**	0.101		**0.101**		0.609	**0.609**

Parantheses denote p-values. The test statistics are calculated based on heteroskedasticity-adjusted robust standard errors.

The implied threshold value from the RE-estimator is selected if the p-value of Hausman test is above >0.05. The corresponding threshold regression is then also implemented with RE, vise versa for FE.

Table 5
Results for Benchmark Model with Exogenous π, Crime Equation
(one-way FE and RE models, plus restricted threshold model)

Conviction rate as proxy

	Average Tax Rates						Marginal Tax Rates					
	Theft			Robbery			Theft			Robbery		
	RE	FE	Restricted Threshold	RE	FE	Restricted Threshold	RE	FE	Restricted Threshold	RE	FE	Restricted Threshold
Probability of escape, π	-13615.120	2707.953	**1898.134**	-276.873	-531.361	**553.462**	-18130.050	-3913.518	**1716.858**	3240.293	3616.233	**888.541**
	(0.017)	(0.794)	**(0.004)**	(0.119)	(0.289)	**(0.001)**	(0.167)	(0.895)	**(0.168)**	(0.326)	(0.196)	**(0.033)**
Escape probability squared, π^2	10471.600	-1164.332		432.530	999.333		13013.400	1542.848		-1832.261	-1976.135	
	(0.009)	(0.872)		(0.018)	(0.173)		(0.144)	(0.930)		(0.391)	(0.268)	
Labour income tax, π_n	158.807	-94.863	**158.751**	-4.130	9.361	**2.370**	-22.891	190.408	**-27.475**	4.875	-3.498	**-5.504**
	(0.000)	(0.542)	**(0.001)**	(0.335)	(0.181)	**(0.693)**	(0.700)	(0.182)	**(0.649)**	(0.511)	(0.365)	**(0.182)**
Capital income tax, π_k	-9.363	-35.169	**-16.427**	-1.645	-2.977	**-2.986**	3.983	24.211	**7.226**	-0.861	1.004	**0.075**
	(0.928)	(0.722)	**(0.881)**	(0.731)	(0.633)	**(0.310)**	(0.898)	(0.200)	**(0.803)**	(0.617)	(0.577)	**(0.956)**
Consumption tax, π_c	85.204	52.100	**72.793**	1.927	-3.927	**-7.955**	70.948	-254.774	**59.216**	6.237	48.287	**46.270**
	(0.110)	(0.601)	**(0.158)**	(0.635)	(0.671)	**(0.019)**	(0.200)	(0.507)	**(0.297)**	(0.343)	(0.049)	**(0.091)**
Gross debt-to-GDP ratio	-2.199	-6.091	**-1.282**	-0.554	0.315	**-0.004**	-5.308	-0.153	**-3.017**	-0.674	0.373	**0.495**
	(0.526)	(0.537)	**(0.711)**	(0.017)	(0.657)	**(0.992)**	(0.552)	(0.993)	**(0.736)**	(0.113)	(0.666)	**(0.631)**
Logarithm of GDP	195.645	3867.592	**212.907**	2.626	-273.103	**-26.639**	441.569	6696.917	**462.310**	9.983	-495.357	**-491.672**
	(0.134)	(0.087)	**(0.114)**	(0.771)	(0.142)	**(0.081)**	(0.036)	(0.082)	**(0.032)**	(0.575)	(0.070)	**(0.072)**
Real GDP growth	-451.868	-1385.473	**-544.504**	-11.383	-6.812	**10.007**	-1298.794	-2989.070	**-912.967**	54.092	-62.507	**-153.576**
	(0.303)	(0.187)	**(0.245)**	(0.845)	(0.898)	**(0.800)**	(0.425)	(0.107)	**(0.525)**	(0.602)	(0.702)	**(0.185)**
Urban population	6.754	-283.819	**12.288**	0.869	1.965	**1.919**	24.112	-381.909	**23.267**	0.675	-0.351	**-3.290**
	(0.542)	(0.156)	**(0.258)**	(0.493)	(0.749)	**(0.399)**	(0.204)	(0.119)	**(0.239)**	(0.773)	(0.964)	**(0.679)**
Unemployment rate	-0.449	99.340	**-0.582**	4.769	-14.101	**-2.689**	-46.096	195.383	**-40.081**	3.764	-18.364	**-21.749**
	(0.988)	(0.289)	**(0.984)**	(0.067)	(0.161)	**(0.353)**	(0.444)	(0.190)	**(0.505)**	(0.498)	(0.042)	**(0.062)**
Working-age population	-29.392	-132.353	**-44.316**	0.239	19.109	**5.676**	-205.850	-362.165	**-220.564**	-0.451	51.059	**59.190**
	(0.536)	(0.263)	**(0.340)**	(0.949)	(0.130)	**(0.146)**	(0.079)	(0.254)	**(0.065)**	(0.965)	(0.030)	**(0.016)**
Country Effect	No	Yes	**No**	No	Yes	**No**	No	Yes	**No**	No	Yes	**Yes**
Time Effect	Yes	Yes	**Yes**	Yes	Yes	**Yes**	Yes	Yes	**Yes**	Yes	Yes	**Yes**
Countries/Observations	57/102	57/102	**57/102**	54/105	54/105	**29/48**	31/66	31/66	**31/66**	30/69	30/69	**30/69**
Overall R^2	0.627	0.006	**0.598**	0.221	0.000	**0.178**	0.457	0.010	**0.426**	0.077	0.018	**0.019**
Hausman test (p-value)	0.678			0.079			0.155			0.007		
Threshold value	0.385		**0.385**	0.781		**0.781**	0.359		**0.359**		0.273	**0.273**

Parantheses denote p-values. The test statistics are calculated based on heteroskedasticity-adjusted robust standard errors.
The implied threshold value from the RE-estimator is selected if the p-value of Hausman test is above >0.05. The corresponding threshold regression is then also implemented with RE, vise versa for FE.

Table 6
Results for Benchmark Model with Exogenous π, Human Capital Equation
(one-way FE and RE models, plus restricted threshold model)

Prosecution rate as proxy

	Average Tax Rates						Marginal Tax Rates					
	Theft			Robbery			Theft			Robbery		
	RE	FE	Restricted Threshold	RE	FE	Restricted Threshold	RE	FE	Restricted Threshold	RE	FE	Restricted Threshold
Crime rate, θ	0.000	0.000	**0.000**	0.000	0.001	**0.001**	0.000	0.000	**0.000**	0.001	0.001	**0.001**
	(0.228)	(0.036)	**(0.237)**	(0.238)	(0.012)	**(0.024)**	(0.532)	(0.034)	**(0.525)**	(0.079)	(0.018)	**(0.001)**
Probability of escape, π	0.162	0.185	**-0.033**	0.123	0.122	**0.141**	-0.087	0.324	**0.023**	0.368	0.316	**-0.129**
	(0.235)	(0.290)	**(0.584)**	(0.125)	(0.296)	**(0.267)**	(0.855)	(0.650)	**(0.468)**	(0.004)	(0.054)	**(0.265)**
Escape probability squared, π^2	-0.118	-0.142		-0.145	-0.090		0.072	-0.208		-0.377	-0.286	
	(0.250)	(0.275)		(0.101)	(0.405)		(0.817)	(0.662)		(0.003)	(0.073)	
Labour income tax, π_n	0.021	0.021	**0.021**	0.029	0.023	**0.024**	-0.012	-0.011	**-0.001**	-0.009	-0.009	**-0.010**
	(0.001)	(0.010)	**(0.001)**	(0.000)	(0.010)	**(0.015)**	(0.007)	(0.011)	**(0.673)**	(0.003)	(0.007)	**(0.009)**
Capital income tax, π_k	-0.011	-0.008	**-0.010**	-0.005	0.001	**0.002**	-0.001	-0.001	**-0.002**	0.000	0.000	**-0.001**
	(0.088)	(0.176)	**(0.123)**	(0.418)	(0.895)	**(0.843)**	(0.656)	(0.602)	**(0.833)**	(0.881)	(0.783)	**(0.469)**
Consumption tax, π_c	0.017	0.010	**0.017**	0.016	0.012	**0.019**	-0.002	0.003	**0.000**	0.004	0.006	**0.015**
	(0.036)	(0.297)	**(0.069)**	(0.013)	(0.110)	**(0.038)**	(0.809)	(0.712)	**(0.476)**	(0.610)	(0.406)	**(0.306)**
Gross debt-to-GDP ratio	0.001	0.001	**0.001**	0.000	0.000	**0.000**	0.000	0.000	**0.005**	0.000	0.000	**-0.001**
	(0.235)	(0.192)	**(0.233)**	(0.514)	(0.619)	**(0.627)**	(0.470)	(0.878)	**(0.349)**	(0.986)	(0.495)	**(0.228)**
Education expenditure	-0.013	-0.002	**-0.013**	-0.024	-0.022	**-0.028**	0.005	0.008	**0.000**	-0.011	-0.009	**-0.013**
	(0.303)	(0.843)	**(0.313)**	(0.035)	(0.038)	**(0.037)**	(0.353)	(0.170)	**(0.942)**	(0.415)	(0.441)	**(0.308)**
Gross enrolment ratio, secondary	-0.001	-0.002	**-0.001**	-0.001	-0.002	**-0.001**	0.000	-0.001	**0.001**	-0.001	-0.001	**-0.001**
	(0.526)	(0.089)	**(0.554)**	(0.332)	(0.026)	**(0.090)**	(0.920)	(0.209)	**(0.733)**	(0.494)	(0.276)	**(0.303)**
Urban population	0.006	0.010	**0.005**	0.004	0.003	**0.002**	0.001	0.008	**0.034**	-0.001	0.000	**-0.002**
	(0.025)	(0.056)	**(0.050)**	(0.114)	(0.503)	**(0.604)**	(0.721)	(0.117)	**(0.000)**	(0.778)	(0.959)	**(0.675)**
Life expectancy	0.032	0.024	**0.033**	0.032	0.033	**0.033**	0.035	0.031	**0.034**	0.032	0.035	**0.019**
	(0.000)	(0.049)	**(0.000)**	(0.001)	(0.038)	**(0.113)**	(0.000)	(0.001)	**(0.000)**	(0.013)	(0.053)	**(0.274)**
Logarithm of total population	0.025	-0.377	**0.026**	0.047	-0.310	**-0.447**	-0.012	-0.944	**-0.011**	-0.018	-0.796	**-0.665**
	(0.572)	(0.283)	**(0.582)**	(0.234)	(0.277)	**(0.126)**	(0.851)	(0.003)	**(0.865)**	(0.767)	(0.068)	**(0.118)**
Country Effect	No	Yes	**No**	No	Yes	**Yes**	No	Yes	**No**	No	Yes	**Yes**
Time Effect	Yes	Yes	**Yes**	Yes	Yes	**Yes**	Yes	Yes	**Yes**	Yes	Yes	**Yes**
Countries/Observations	48/93	48/93	**46/88**	47/98	47/99	**42/83**	27/67	27/67	**26/66**	26/71	26/71	**24/60**
Overall R^2	0.341	0.076	**0.342**	0.365	0.017	**0.005**	0.073	0.003	**0.071**	0.007	0.007	**0.014**
Hausman test (p-value)	0.099			0.006			0.129			0.026		
Threshold value	0.366		**0.366**		0.369	**0.369**	0.418		**0.418**		0.453	**0.453**

Parantheses denote p-values. The test statistics are calculated based on heteroskedasticity-adjusted robust standard errors.

The implied threshold value from the RE-estimator is selected if the p-value of Hausman test is above >0.05. The corresponding threshold regression is then also implemented with RE, vise versa for FE.

Table 7

Results for Benchmark Model with Exogenous π, Human Capital Equation

(one-way FE and RE models, plus restricted threshold model)

Conviction rate as proxy

	Average Tax Rates						Marginal Tax Rates					
	Theft			Robbery			Theft			Robbery		
	RE	FE	Restricted Threshold	RE	FE	Restricted Threshold	RE	FE	Restricted Threshold	RE	FE	Restricted Threshold
Crime rate, θ	0.000	0.000	**0.000**	0.000	0.000	**0.000**	0.000	0.000	**0.000**	0.000	0.000	**0.000**
	(0.045)	(0.001)	**(0.000)**	(0.738)	(0.763)	**(0.875)**	(0.087)	(0.003)	**(0.001)**	(0.462)	(0.732)	**(0.178)**
Probability of escape, π	0.830	0.602	**-0.033**	0.342	0.470	**0.116**	0.072	-0.165	**0.076**	0.489	0.629	**-0.054**
	(0.074)	(0.237)	**(0.682)**	(0.097)	(0.034)	**(0.476)**	(0.943)	(0.821)	**(0.358)**	(0.087)	(0.016)	**(0.696)**
Escape probability squared, π^2	-0.656	-0.426		-0.237	-0.196		-0.105	0.157		-0.304	-0.352	
	(0.037)	(0.223)		(0.315)	(0.331)		(0.870)	(0.739)		(0.307)	(0.116)	
Labour income tax, π_n	0.013	0.009	**0.009**	0.021	0.017	**0.015**	-0.008	-0.009	**-0.010**	-0.007	-0.007	**-0.005**
	(0.031)	(0.240)	**(0.238)**	(0.008)	(0.058)	**(0.139)**	(0.079)	(0.034)	**(0.021)**	(0.030)	(0.077)	**(0.202)**
Capital income tax, π_k	-0.014	-0.008	**-0.007**	-0.007	-0.005	**-0.006**	0.001	0.000	**0.000**	-0.001	0.000	**-0.001**
	(0.026)	(0.119)	**(0.167)**	(0.221)	(0.423)	**(0.507)**	(0.604)	(0.783)	**(0.790)**	(0.607)	(0.846)	**(0.661)**
Consumption tax, π_c	0.000	0.003	**0.004**	0.010	0.006	**0.002**	0.003	0.011	**0.011**	-0.004	0.000	**-0.004**
	(0.950)	(0.763)	**(0.682)**	(0.289)	(0.598)	**(0.910)**	(0.761)	(0.122)	**(0.149)**	(0.675)	(0.963)	**(0.670)**
Gross debt-to-GDP ratio	0.000	0.000	**0.000**	0.000	0.000	**0.000**	0.001	0.000	**0.000**	0.000	0.000	**0.000**
	(0.482)	(0.477)	**(0.473)**	(0.824)	(0.427)	**(0.666)**	(0.512)	(0.927)	**(0.890)**	(0.948)	(0.635)	**(0.986)**
Education expenditure	-0.009	-0.002	**-0.003**	-0.032	-0.020	**-0.017**	-0.004	-0.002	**-0.002**	-0.015	-0.005	**-0.004**
	(0.290)	(0.720)	**(0.663)**	(0.020)	(0.076)	**(0.131)**	(0.653)	(0.669)	**(0.651)**	(0.328)	(0.647)	**(0.685)**
Gross enrolment ratio, secondary	0.001	0.000	**-0.001**	0.001	0.000	**0.000**	0.000	-0.001	**-0.001**	0.001	0.000	**0.000**
	(0.637)	(0.767)	**(0.679)**	(0.437)	(0.921)	**(0.815)**	(0.751)	(0.168)	**(0.173)**	(0.530)	(0.961)	**(0.948)**
Urban population	0.008	0.010	**0.010**	0.005	0.003	**0.001**	0.006	0.013	**0.013**	-0.002	-0.001	**-0.006**
	(0.011)	(0.032)	**(0.044)**	(0.072)	(0.533)	**(0.825)**	(0.258)	(0.005)	**(0.005)**	(0.690)	(0.746)	**(0.238)**
Life expectancy	0.029	0.029	**0.027**	0.025	0.001	**-0.014**	0.018	0.025	**0.023**	0.015	0.002	**-0.022**
	(0.002)	(0.085)	**(0.108)**	(0.016)	(0.936)	**(0.631)**	(0.177)	(0.038)	**(0.040)**	(0.341)	(0.899)	**(0.288)**
Logarithm of total population	0.016	-0.677	**-0.687**	0.008	-0.627	**-0.660**	-0.007	-1.341	**-1.332**	-0.049	-1.102	**-1.091**
	(0.677)	(0.032)	**(0.026)**	(0.851)	(0.067)	**(0.121)**	(0.912)	(0.000)	**(0.000)**	(0.377)	(0.009)	**(0.004)**
Country Effect	No	Yes	**Yes**	No	Yes	**Yes**	No	Yes	**Yes**	No	Yes	**Yes**
Time Effect	Yes	Yes	**Yes**	Yes	Yes	**Yes**	Yes	Yes	**Yes**	Yes	Yes	**Yes**
Countries/Observations	53/108	53/108	**53/108**	51/111	51/111	**49/102**	31/79	31/79	**31/78**	31/83	31/83	**29/77**
Overall R^2	0.335	0.036	**0.033**	0.386	0.009	**0.000**	0.1036	0.0048	**0.006**	0.102	0.009	**0.036**
Hausman test (p-value)	0.049			0.018			0.006			0.021		
Threshold value		0.354	**0.354**		0.209	**0.209**		0.474	**0.474**		0.280	**0.280**

Parantheses denote p-values. The test statistics are calculated based on heteroskedasticity-adjusted robust standard errors.

The implied threshold value from the RE-estimator is selected if the p-value of Hausman test is above >0.05. The corresponding threshold regression is then also implemented with RE, vise versa for FE.

Table 8
Three-stage-least squares (3SLS) estimation results for the system of 4 equations, with endogenousπ
Prosecution rate as proxy

	Average Tax Rates								Marginal Tax Rates							
	Theft				Robbery				Theft				Robbery			
	Crime	Human Capital	Probability	Growth	Crime	Human Capital	Probability	Growth	Crime	Human Capital	Probability	Growth	Crime	Human Capital	Probability	Growth
Crime rate, θ		0.000		0.000		-0.002		0.000		0.000		0.000		0.000		0.000
		(0.470)		(0.000)		(0.058)		(0.588)		(0.403)		(0.893)		(0.566)		(0.520)
Probability of escape, π	-4745.524	4.083			-627.030	1.808			14122.670	4.892			-842.260	1.349		
	(0.331)	(0.046)			(0.054)	(0.153)			(0.116)	(0.002)			(0.003)	(0.060)		
Escape probability squared, π^2	6029.031	-3.017			723.963	-1.527			-6884.327	-3.343			1089.000	-1.339		
	(0.115)	(0.069)			(0.019)	(0.226)			(0.286)	(0.003)			(0.000)	(0.050)		
Labour income tax, π_n	142.732	-0.015			-7.683	-0.009			-10959.430	0.001			-191.627	1.013		
	(0.000)	(0.344)			(0.015)	(0.527)			(0.186)	(0.999)			(0.613)	(0.305)		
Capital income tax, π_k	-28.760	0.015			-24.194	-0.001			59.717	0.021			-4.140	0.015		
	(0.793)	(0.646)			(0.006)	(0.985)			(0.062)	(0.000)			(0.012)	(0.000)		
Consumption tax, π_c	99.692	0.060			2.188	0.073			160.208	0.024			-7.767	0.016		
	(0.162)	(0.002)			(0.710)	(0.000)			(0.005)	(0.003)			(0.002)	(0.024)		
Human capiral				0.158				0.128				-2.393				-2.539
				(0.831)				(0.870)				(0.127)				(0.164)
Human capital, squared				-0.077				-0.054				0.319				0.350
				(0.556)				(0.691)				(0.199)				(0.224)
Expenditure on public order & security			0.209				0.354				0.212				0.408	
			(0.230)				(0.095)				(0.178)				(0.045)	
POS expenditure, squared			-0.056				-0.115				-0.065				-0.109	
			(0.167)				(0.021)				(0.063)				(0.018)	
Gross debt-to-GDP ratio	-0.761	-0.004			-1.033	-0.005			-1.294	-0.003			-0.616	-0.002		
	(0.904)	(0.027)			(0.022)	(0.001)			(0.893)	(0.013)			(0.115)	(0.088)		
Education expenditure		0.026				-0.001				0.119				0.037		
		(0.638)				(0.985)				(0.011)				(0.281)		
Gross enrolment ratio, secondary		0.004				-0.002				-0.008				-0.005		
		(0.324)				(0.594)				(0.025)				(0.050)		
Logarithm of GDP	287.686			0.023	6.653			0.021	619.720			0.033	-19.501			0.018
	(0.015)			(0.137)	(0.525)			(0.186)	(0.001)			(0.001)	(0.133)			(0.113)
Real GDP growth	-153.730				-184.252				-919.813				-490.997			
	(0.862)				(0.021)				(0.680)				(0.000)			
Unemployment rate	33.660				-3.383				7.911				-2.899			
	(0.354)				(0.240)				(0.902)				(0.309)			
Working-age population	-53.795				-6.254				-134.363				10.067			
	(0.311)				(0.254)				(0.262)				(0.209)			
Urban population	5.974	0.001	0.003		0.891	0.006	0.002		41.263	0.001	0.002		-2.415	0.003	0.005	
	(0.635)	(0.885)	(0.231)		(0.428)	(0.103)	(0.512)		(0.069)	(0.737)	(0.410)		(0.037)	(0.383)	(0.172)	
Life expectancy		0.026	0.026			0.029	0.018			0.026	0.022			0.012	0.027	
		(0.170)	(0.002)			(0.035)	(0.068)			(0.121)	(0.059)			(0.370)	(0.057)	
Logarithm of total population		0.161	-0.011			0.184	-0.006			0.174	-0.006			0.102	0.010	
		(0.000)	(0.571)			(0.000)	(0.773)			(0.000)	(0.746)			(0.000)	(0.659)	
Investment				0.020				0.011				0.013				0.012
				(0.000)				(0.008)				(0.000)				(0.000)
Trade				0.000				0.000				0.001				0.000
				(0.546)				(0.848)				(0.045)				(0.343)
Inflation				-0.001				-0.002				-0.016				-0.014
				(0.256)				(0.013)				(0.000)				(0.000)
Country Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	57	57	57	57	61	61	61	61	41	41	41	41	45	45	45	45
Adjusted R^2	0.754	0.497	0.346	0.423	0.460	0.461	0.297	0.336	0.661	0.528	0.368	0.722	0.449	0.625	0.386	0.566
Implied threshold values	**0.635**	**0.369**	**0.135**		**0.577**	**0.422**	**0.162**		**0.244**	**0.342**	**0.152**		**0.646**	**0.496**	**0.133**	

Parantheses denote p-values.

Table 9

Three-stage-least squares (3SLS) estimation results for the system of 4 equations, with endogenous π

Conviction rate as proxy

	Average Tax Rates								Marginal Tax Rates							
	Theft				Robbery				Theft				Robbery			
	Crime	Human Capital	Probability	Growth	Crime	Human Capital	Probability	Growth	Crime	Human Capital	Probability	Growth	Crime	Human Capital	Probability	Growth
Crime rate, θ		0.001		0.000		-0.005		0.000		0.000		0.000		-0.003		0.000
		(0.000)		(0.000)		(0.000)		(0.030)		(0.000)		(0.656)		(0.000)		(0.366)
Probability of escape, π	-69207.500	34.885			-856.351	10.736			-29391.870	14.721			505.831	4.738		
	(0.000)	(0.000)			(0.477)	(0.001)			(0.098)	(0.000)			(0.831)	(0.345)		
Escape probability squared, π^2	46982.430	-23.665			854.049	-6.818			19861.100	-9.917			-339.794	-2.429		
	(0.000)	(0.000)			(0.355)	(0.003)			(0.083)	(0.000)			(0.839)	(0.483)		
Labour income tax, π_n	151.944	-0.057			-5.780	-0.012			-2785.856	0.466			1.553	0.897		
	(0.000)	(0.002)			(0.121)	(0.502)			(0.753)	(0.790)			(0.998)	(0.595)		
Capital income tax, π_k	-83.636	0.072			-10.908	-0.067			17.839	0.009			-2.252	-0.001		
	(0.573)	(0.162)			(0.357)	(0.154)			(0.558)	(0.122)			(0.455)	(0.856)		
Consumption tax, π_c	186.589	-0.091			3.993	0.057			100.232	-0.032			1.755	0.005		
	(0.018)	(0.001)			(0.569)	(0.027)			(0.035)	(0.000)			(0.665)	(0.618)		
Human capiral				-1.054				-0.671				0.125				-0.289
				(0.103)				(0.308)				(0.902)				(0.781)
Human capital, squared				0.130				0.092				-0.057				0.017
				(0.249)				(0.415)				(0.727)				(0.917)
Expenditure on public order & security			0.016				0.028				-0.013				0.037	
			(0.836)				(0.743)				(0.852)				(0.563)	
POS expenditure, squared			-0.007				-0.018				-0.003				-0.012	
			(0.726)				(0.421)				(0.859)				(0.510)	
Gross debt-to-GDP ratio	-5.845	-0.001			-0.192	-0.009			-0.034	0.000			-0.823	-0.003		
	(0.442)	(0.568)			(0.768)	(0.000)			(0.997)	(0.936)			(0.276)	(0.089)		
Education expenditure		-0.010				-0.040				-0.101				-0.055		
		(0.844)				(0.538)				(0.090)				(0.249)		
Gross enrolment ratio, secondary		0.000				-0.005				0.001				0.001		
		(0.965)				(0.226)				(0.727)				(0.680)		
Logarithm of GDP	268.218			0.008	-10.080			0.011	394.658			0.014	33.597			0.002
	(0.022)			(0.597)	(0.586)			(0.480)	(0.023)			(0.161)	(0.112)			(0.853)
Real GDP growth	-2705.012				365.069				-5684.741				630.271			
	(0.024)				(0.004)				(0.012)				(0.006)			
Unemployment rate	-2.913				6.230				-124.137				5.145			
	(0.901)				(0.044)				(0.002)				(0.156)			
Working-age population	75.332				11.853				-168.593				-20.645			
	(0.158)				(0.259)				(0.140)				(0.058)			
Urban population	5.119	0.000	0.003		4.150	0.012	-0.001		25.819	-0.010	0.007		-1.087	0.001	0.002	
	(0.751)	(0.993)	(0.022)		(0.027)	(0.082)	(0.755)		(0.308)	(0.041)	(0.001)		(0.638)	(0.815)	(0.493)	
Life expectancy		0.003	0.008			0.038	0.010			0.000	-0.006			-0.006	0.015	
		(0.815)	(0.101)			(0.026)	(0.076)			(0.990)	(0.426)			(0.777)	(0.057)	
Logarithm of total population		-0.077	-0.002			0.206	0.010			-0.082	0.019			0.037	0.024	
		(0.079)	(0.888)			(0.000)	(0.446)			(0.044)	(0.123)			(0.419)	(0.050)	
Investment				0.019				0.012				0.013				0.012
				(0.000)				(0.001)				(0.000)				(0.000)
Trade				0.000				0.000				0.001				0.000
				(0.608)				(0.640)				(0.095)				(0.811)
Inflation				0.000				-0.001				-0.013				-0.009
				(0.444)				(0.088)				(0.000)				(0.002)
Country Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	67	67	67	67	69	69	69	69	48	48	48	48	52	52	52	52
Adjusted R2	0.530	0.030	0.231	0.197	0.134	0.058	0.160	0.259	0.545	0.040	0.351	0.595	0.075	0.045	0.325	0.412
Implied threshold values	**0.339**	**0.339**	**0.220**		**0.499**	**0.318**	**0.333**		**0.338**	**0.337**	**NA**		**0.336**	**0.256**	**0.166**	

Parantheses denote p-values.