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The juvenile crime dilemma

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ABSTRACT

I develop a dynamic model of behavior to analyze juvenile crime. Forward-looking youths consistently decide between crime and legal activities depending on their endowment of work- and crime-specific human capital, which in turn is shaped by their history of past choices. The model explicitly recognizes the contrasting levels of punishment of the juvenile and adult criminal systems. In order to evaluate whether the model explains the evolution of crime, I calibrate it and test whether it can account for the observed variations in juvenile crime levels across changes in economic and legal conditions. The model is able to reproduce 91 percent of the recent increase in juvenile crime in Uruguay by affecting key model parameters in line with observed facts (a decrease in the relative returns of legal activities and the introduction of a lenient juvenile crime regulation and enforcement strategy). Counterfactual model results predict that a reduction in the age of criminal majority would significantly lower juvenile crime involvement. However, if the transmission of crime-related skills in correctional facilities were strong enough, harsher punishments to juveniles would increase the likelihood of criminal involvement later in life.

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1. Introduction

Juvenile delinquency is at the forefront of social challenges worldwide. The delicate intersection between childhood and criminality creates a complex dilemma to solve. This concern cuts across economic development categories and geographical regions as youth crime rates rose in almost every part of the world in the 1990s (United Nations, 2004, 2007).² Only in the US, more than 70,000 juveniles are jailed in detention centers (OJJDP, 2011).

The literature has found several determinants of juvenile criminal involvement (Levitt and Lochner, 2000). Biological factors, such as being male and having low intelligence, are accurate predictors of crime. Family background factors such as erratic parental discipline, lack of adequate supervision and maternal rejection are also strongly correlated with later criminal involvement. Following Becker (1968), juvenile delinquency can also be thought of as a rational response to the

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² Juvenile offending refers to a wide range of violations of legal and social norms, from minor offenses to serious crimes. The focus of this paper is on serious juvenile crime.

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incentives for engaging in legal and criminal activities. Some youths will engage in criminal behavior if the potential gains are large enough while the expected punishment is relatively low.

Juvenile crime is usually treated quite differently from adult crime. Offenses committed by youths are considered delinquent acts within a separate justice system. This system is designed to recognize the special needs and immature status of adolescents by emphasizing rehabilitation over punishment. Juvenile criminal records are sealed from adult courts and public record, arrested youths are judged by juvenile courts, and convicted minors are strictly segregated from adults in custody. Psychological research supports this differential treatment based on the developmental immaturity of adolescents (Steinberg, 2009). However, in the fight against juvenile delinquency, several countries are considering trying violent juvenile offenders as adults in court.

Beyond psychological concerns, invoking the heavy hand of the adult criminal justice system might raise relevant issues of intertemporal choice and have ambiguous effects on the incentives for criminal involvement. The negative signal generated by court records, or the acquisition of criminal-specific human capital in correctional facilities could offset the potential reduction in juvenile crime achieved through deterrence from harsher punishments.

To tackle these issues, I develop a new dynamic model of crime in which youths face the dilemma to choose between crime and legal activities and decisions are affected by their endowments of work- and crime-related skills, which in turn depend upon both their current and past choices. In this model, youths are forward-looking and recognize that their present choices affect their future skills and income. This path dependence incorporates individual heterogeneity since agents with contrasting records face external incentives to commit crime in different ways and thus exhibit divergent behaviors.

Because the model developed in this paper is designed to explain juvenile crime, it accounts for the fact that key factors affecting individual decisions are significantly different before and after the age of criminal majority (the age at which individuals become subject to adult courts). The probability of apprehension, the level of punishment, and the probability of escape from correctional facilities differ for those below and above this threshold.

This framework differs from the models developed in the literature. In static models of crime, agents make choices with no regard for future consequences of current decisions (Becker, 1968; Ehrlich, 1973; Block and Heineke, 1975; Witte, 1980). With only few exceptions (Imai and Krishna, 2004; Merlo and Wolpin, 2009; Sickles and Williams, 2008), previous dynamic models of crime do not emphasize the life cycle aspect of criminal behavior (Flinn, 1986; Imrohorglu et al., 2004; Burdett et al., 2003, 2004; Huang et al., 2004; Lochner, 2004; Mocan et al., 2005; McCrary, 2010). Only Mocan et al. (2005) explores a dynamic model of crime where agents are endowed with two types of human capital. Most importantly, to the best of my knowledge there are no models in the literature specifically designed to account for the change in key parameters at the age of criminal majority.

Substantial changes in juvenile crime incentives make Uruguay an ideal environment to calibrate and test this model. The dynamics of wages and household wealth after a serious economic crisis have resulted in financial rewards from criminal activities exceeding returns from the job market. Additionally, the introduction of a lenient juvenile crime regulation and an increase in the escape rate from juvenile correctional facilities substantially lowered the expected cost of crime. At the same time, juvenile crime more than tripled between 2001 and 2010. This massive spike in youth delinquency has triggered a strong debate over the threshold age of criminal responsibility.

The calibrated model is able to reproduce 91 percent of the recent increase in juvenile crime in Uruguay by affecting key model parameters in line with observed facts. According to the model, the evolution of the returns to legal activities relative to the monetary gains from crime explains 43 percent of the variation in juvenile delinquency from 2001 to 2010. Additionally, the approval of a lenient juvenile criminal regulation in 2004 meant to align local legislation with international treaties and agreements played a key role, explaining an additional 33 percent of the observed variation. The significant increase in escapes from juvenile correctional facilities explains an additional 4 percent of the increase in juvenile crime.

The model provides a framework to quantify the effectiveness of alternative measures in the fight against juvenile crime. Counterfactual model results predict that lowering the age of criminal majority from 18 to 16 would significantly reduce juvenile crime involvement. However, special care should be taken to minimize the school-of-crime effect, according to which inmates learn criminal skills in correctional facilities. If the transmission of crime-related skills were strong enough, the cure could prove to be worse than the disease, as the model predicts that harsher punishments may increase the likelihood of criminal involvement once today's juveniles enter adulthood.

The remainder of the paper is organized as follows. Section 2 presents the model. Section 3 calibrates the model for Uruguay, and Section 4 tests its ability to explain the recent spike in juvenile crime. Section 5 discusses alternative measures to fight juvenile delinquency. Section 6 concludes.

2. The model

In this section, I develop a dynamic model to analyze juvenile behavior. Heterogeneous youths choose a strategy composed of an action for the current period and a set of actions for the subsequent periods of their working lives in order to maximize their discounted expected income: $E_t \sum_{t=0}^T \beta^t y_t$. E_t is the expectation operator conditional on information available at time t , T is the age of retirement, β is the subjective discount factor, and y_t is the level of income at time t . Every period, individuals face legal and criminal opportunities and choose between legal activities (studying and working) and crime. Agents are endowed with two different types of human capital, work-related skills H and crime-related skills B , which evolve in accordance with their choices.

Table 1
Law of motion of skills.

	$H_{t+1} =$	$B_{t+1} =$
Study	$H_t + \mu_i$ with $\mu_i > 0$	B_t
Work	$H_t + \alpha_i$ with $\alpha_i > 0$	B_t
Crime + Free	H_t	$B_t + \chi_i$ with $\chi_i > 0$
Crime + Escape	$H_t - \eta(H_t)_i$ with $\eta(H_t)_i > 0$ and $\frac{\partial \eta(H_t)_i}{\partial H_t} > 0$	$B_t + \chi_i$ with $\chi_i > 0$
Crime + Sentence	$H_t - \eta(H_t)_i$ with $\eta(H_t)_i > 0$ and $\frac{\partial \eta(H_t)_i}{\partial H_t} > 0$	$B_t + \gamma_i$ with $\gamma_i > 0$

If the agents decide to study, they have no income in the current period and are free to choose to study, work or commit crime the following period.

If the agents decide to work, they accept an independent wage rate per unit of work-related skill w drawn from the time-invariant distribution $F(w) = \Pr(w_t \leq w)$. Earnings during this period are a product of the wage rate offered and the agent's level of work-related skills. Working agents are then free to choose to study, work or commit crime the following period.

If the agents decide to engage in criminal activities, they run the risk of apprehension, which occurs with probability P . Detained agents are unable to realize the gains from crime. Agents who serve their prescribed sentences are convicted for s periods, including pre-trial detention time. Income is zero for the duration of the sentence, and once released agents are able to choose again between studying, working and committing crime. Individuals are able to escape from detention centers with probability ε . Agents who escape from correctional facilities also receive zero income during the current period and are free to choose between studying, working and committing crime the following period.³ The current income of agents who engage in crime and evade police apprehension depends on the monetary gains from crime per unit of crime-related skills g and on their level of crime-related skills. Those agents are then free to choose between studying, working and committing crime the following period.

In every case, the continuation value in the following period depends on the realization of the wage rate, on whether the agents are in jail or free, on how their work-related skills and crime-related skills evolved since the previous period and on the age of the agents.

Key factors affecting individual decisions are significantly different before and after the age of majority τ . The probability of apprehension, the level of punishment upon apprehension and the probability of escape from correctional facilities are significantly more permissive for youths than for adults.

Therefore, the value of the optimization problem for individuals with work-related skills H_t and crime-related skills B_t , who observe a realization of w_t at age t , is given by:

$$V(w_t, H_t, B_t, t) = \max_{\text{study, work, crime}} \left\{ \begin{array}{l} \underbrace{\beta E_t V(w_{t+1}, H_{t+1}, B_{t+1}, t+1)}_{\text{study}} \\ \underbrace{w_t H_t + \beta E_t V(w_{t+1}, H_{t+1}, B_{t+1}, t+1)}_{\text{work}} \\ P_i(1 - \varepsilon_i) \underbrace{[\beta^{s_i} E_t V(w_{t+s_i}, H_{t+s_i}, B_{t+s_i}, t+s_i)]}_{\text{crime+sentence}} \\ + \underbrace{P_i \varepsilon_i \beta E_t V(w_{t+1}, H_{t+1}, B_{t+1}, t+1)}_{\text{crime+escape}} \\ + \underbrace{(1 - P_i) [g B_t + \beta E_t V(w_{t+1}, H_{t+1}, B_{t+1}, t+1)]}_{\text{crime+free}} \end{array} \right\}$$

$$\text{where } i = \begin{cases} j \text{ (i.e. juveniles) for } t \text{ such that } 0 \leq t < \tau \\ a \text{ (i.e. adults) for } t \text{ such that } \tau \leq t \leq T \end{cases} \quad (1)$$

There is a finite number of both skill sets whose dynamics depend upon the agents' choices. Table 1 describes the laws of motion of the state variables H_t and B_t .

Work-related skills increase for agents who decide to study due to schooling effects and for agents who decide to work due to on-the-job-training, while in both cases the level of crime-related skills remains unchanged. Agents who commit crime but evade capture maintain the same level of work-related skills and see an increase in their crime-related skills due to on-the-crime-training. Agents who decide to engage in criminal activities who, after getting caught, manage to escape from custody before serving the mandated sentence face a depreciation of their work-related skills due to their possession of a criminal record (the higher the level of work-related skills, the stronger the depreciation) and an appreciation in

³ I assume escapes occur on the following period and do not increase the potential sentence.

their crime-related skills due to on-the-crime-training. Finally, agents who decide to engage in criminal activities who, after getting caught, serve the mandated sentence see their work-related skills depreciate and their crime-related skills appreciate due to both on-the-crime-training and the school-of-crime effect of incarceration.

The endogenous evolution of skills recognizes both the stigmatizing effect and the school-of-crime effect of incarceration. The stigmatizing effect refers to the fact that ex-offenders' earnings are low, even after controlling for their weak labor market characteristics (Grogger, 1995; Holzer, 2007). Not only does incarceration erode job skills but, most importantly, a criminal record signals to employers that a potential employee is untrustworthy. The hypothesis that prisons are schools of crime also has widespread support. Empirical literature suggests that the social environment of correctional facilities is criminogenic (Chen and Shapiro, 2007; Bayer et al., 2009; Camp and Gaes, 2009; DeLisi et al., 2011; Fagan et al., 2013). Moreover, recent empirical evidence clearly shows that individuals with an incarceration history earn a significantly higher annual income from criminal activity compared to respondents without an incarceration history (Hutcherson, 2012; Fagan et al., 2013). The intensity of both effects is different for juveniles and adults since juvenile criminal records are usually sealed and convicted youths are segregated from adults in custody.

Combining Eq. (1) with the laws of motion stated in Table 1, I get the following recursive formulation:

$$V(w_t, H_t, B_t, t) = \max_{\text{study, work, crime}} \left\{ \begin{aligned} & \beta \int_{w_{t+1}} V(w_{t+1}, H_t + \mu_i, B_t, t + 1) dF(w_{t+1}), \\ & w_t H_t + \beta \int_{w_{t+1}} V(w_{t+1}, H_t + \alpha_i, B_t, t + 1) dF(w_{t+1}), \\ & P_i(1 - \varepsilon_i) [\beta^{s_i} \int_{w_{t+s_i}} V(w_{t+s_i}, H_{t-s_i} - s_i \eta(H)_i, B_{t-s_i} + s_i \gamma_i, t + s_i) dF(w_{t+s_i})] \\ & + P_i \varepsilon_i [\beta \int_{w_{t+1}} V(w_{t+1}, H_t - \eta(H)_i, B_t + \chi_i, t + 1) dF(w_{t+1})] \\ & + (1 - P_i) [g B_t + \beta \int_{w_{t+1}} V(w_{t+1}, H_t, B_t + \chi_i, t + 1) dF(w_{t+1})] \end{aligned} \right\} \quad (2)$$

where dF denotes the probability density function of the wage rate per unit of work-related skill.

Assuming no population growth, I obtain the juvenile equilibrium dynamic behavior by solving the problem through backward induction, starting from the last period of the agents' working lives.

Let $S(w_t, H, B, t) = 1$ if the agent in state (w_t, H, B, t) studies, let $W(w_t, H, B, t) = 1$ if the agent in state (w_t, H, B, t) works, and let $C(w_t, H, B, t) = 1$ if the agent in state (w_t, H, B, t) commits crime. Then, $J(w_t, H, B, t)$ is the number of free agents with work-related skills H and crime-related skills B facing w_t at age t conditional on a given history of realizations of w , and evolving according to the following recursive equation:

$$J(w_t, H, B, t) = [S(w_{t-1}, H - \mu_j, B, t - 1)] J(w_{t-1}, H - \mu_j, B, t - 1) + [W(w_{t-1}, H - \alpha_j, B, t - 1)] J(w_{t-1}, H - \alpha_j, B, t - 1) + (1 - P_j) C(w_{t-1}, H, B - \chi_j, t - 1) J(w_{t-1}, H, B - \chi_j, t - 1) + P_j \varepsilon_j C(w_{t-1}, H + \eta(H)_j, B - \chi_j, t - 1) J(w_{t-1}, H + \eta(H)_j, B - \chi_j, t - 1) + \left[\begin{aligned} & P_j(1 - \varepsilon_j) C(w_{t-1-s_j}, H + s_j \eta(H)_j, B - s_j \gamma_j, t - s_j) \\ & \cdots J(w_{t-1-s_j}, H + s_j \eta(H)_j, B - s_j \gamma_j, t - s_j) \end{aligned} \right] \quad (3)$$

The first term on the right hand side of Eq. (3) denotes the number of juveniles with work-related skills $H - \mu_j$ and crime-related skills B who faced a wage w_{t-1} and decided to study at $t - 1$. The second term denotes the number of juveniles with work-related skills $H - \alpha_j$ and crime-related skills B who faced a wage w_{t-1} and decided to work at $t - 1$. The third term represents those juveniles with work-related skills H and crime-related skills $B - \chi_j$ who faced wage w_{t-1} , committed crime at $t - 1$ and evaded apprehension. The fourth term represents those youths with work-related skills $H + \eta(H)_j$ and crime-related skills $B - \chi_j$ who faced wage w_{t-1} , committed crime at $t - 1$, and after getting caught immediately escaped from the detention center. Finally, the last term represents those convicted juveniles with work-related skills $H + s_j \eta(H)_j$ and crime-related skills $B - s_j \gamma_j$ who faced wage w_{t-1-s_j} , committed crime at $t - 1 - s_j$, and are free by t per their sentence length.

Therefore, the total number of 13–17 year-old agents endowed with every possible combination of work- and crime-related skills who decide to commit crime after observing the realizations of the wage rate per unit of work-related skill is given by:

$$JC = \int_w \sum_H \sum_B \sum_{t=0}^{\tau-1} J(w_t, H, B, t) C(w_t, H, B, t) dF(w_t) \quad (4)$$

3. Calibration

In this section, I calibrate the model to fit the juvenile crime rates observed in Uruguay in 2001, before the 2002 economic and financial crisis and the introduction of relevant changes to juvenile crime regulation.

Table 2
Key parameters.

Parameter	Juveniles ($i = j$)	Adults ($i = a$)
P_i	10%	10%
s_i	2Q	3Q
ε_i	15%	0
μ_i	0.045	0.045
α_i	0.0075	0.0075
χ_i	0.0075	0.0075
γ_i	0.09	0.09
$\eta_i H_{q1}$	0	0.0225
$\eta_i H_{q2}$	0	0.03
$\eta_i H_{q3}$	0	0.0375
$\eta_i H_{q4}$	0	0.045
$\eta_i H_{q5}$	0	0.0525

Note: H_{q1} – H_{q5} refer to quintiles to work-related skills.

Each time period is a quarter and agents live for 200 quarters (or 50 years) starting at the age of 13. I fix the discount factor β to 0.986, or just under 6 percent annually. This shorter-than-usual time horizon is consistent with evidence that concern about the future and the ability to plan ahead increase along the lifespan (Nurmi, 1991; Green et al., 1994, 1996, 1999; Steinberg et al., 2009).

Table 2 depicts estimates of key parameters for 2001 Uruguay, including the probability of apprehension, the average effective sentence length, the probability of escape from correctional facilities and the parameters that govern the evolution of skills.

I estimate the 10 percent probability of apprehension (P_i) as the ratio of total prosecutions to total offenses after adjusting data on police-recorded offenses for an underreporting rate of 55 percent (Aboal et al., 2013).⁴ I assume an equal probability of apprehension for both juveniles and adults, as the police do not make distinctions between the two at the time of the arrest.

Based on judicial statistics, I estimate the effective average sentence length by looking at the ratio of convictions to prosecutions and the observed average sentence length of those convicted. For juveniles, the effective average sentence length (s_j) was 2 quarters, as the ratio of conviction to prosecution was 0.51 and the average sentence length was 11.9 months (Lopez and Palummo, 2013). For adults, the effective average sentence length (s_a) was 3 quarters, as the conviction to prosecution rate was 0.66 and the average sentence length of the adult prison population was 15 months. The average sentence length for adults is computed from records of entries to and exits from Uruguay's main correctional facility between 2002 and 2010.⁵

I compute the probability of escape (ε_i) as the ratio of the number of prison breaks and the total number of inmates. In 2001, this probability was 15 percent for youths and 0.4 percent for adults.

I set 135 different skill levels by evenly partitioning the interval [1, 2]. An agent endowed with the lowest-possible skill level who starts working will reach the highest-possible skill level after 25 years, conditional on working continuously through every period. I estimate the initial distribution of work-related skills by using the results of the 2003 OECD Programme for International Student Assessment (PISA).⁶ By design, PISA test scores reflect job market aptitude for a representative sample of youths. Due to a lack of evidence to suggest otherwise, I assume a uniform distribution of crime-related skills.

If individuals decide to study, their work-related skills increase by $\mu = 0.045$ units in the interval [1, 2]. Put differently, the annual growth rate of work-related skills ranges from 19.2 percent at the lowest skill levels to 9.6 at the highest skill levels, in line with estimates of returns to schooling in Uruguay (Sanroman, 2006). Crime-related skills remain constant.

If individuals decide to work, their work-related skills increase by $\alpha = 0.0075$ units in the interval [1, 2]. In other words, the annual growth rate of work-related skills ranges from 3.2 percent at the lowest skill levels to 1.6 percent at the highest skill levels, again in line with estimates for Uruguay (Sanroman, 2006). Agents who have reached the highest work-related skill levels retain those skills until committing crime or retiring. Crime-related skills again remain constant.

If agents commit crime and remain free or escape from custody, their crime-related skills increase due to on-the-crime-training by $\chi = 0.0075$ units in the interval [1, 2]. This growth rate is the same to the one found in the literature for work-related skills due to on-the-job-training (Hutcherson, 2012).

Additionally, if agents are apprehended after committing crime and serve the mandated sentence, the evolution of crime-related skills given by $\gamma = 0.09$ depends both on on-the-crime training and the school-of-crime effect in correctional

⁴ This figure was computed from official victimization surveys and is similar to the rates estimated for the US (Levitt, 1996) and Chile (Nuñez et al., 2003).

⁵ According to Prisoner Ombudsman Alvaro Garcé, inmates at ComCar (which houses 35 percent of the country's prison population) are representative of the Uruguayan urban offender population.

⁶ Uruguay first participated in PISA in 2003.

Table 3

Factors affecting juvenile crime's dynamics.

Parameter	Baseline	(1)	(2)	(3)	(4)	(5)
		Wages/Loot	Juv. code	(1) + (2)	Escapes	(3) + (4)
\bar{w}/g	1.9	1.9/1.22	1.9	1.9/1.22	1.9	1.9/1.22
P_j	10%	10%	6%	6%	10%	6%
s_j	2	2	1	1	2	1
ε_j	15%	15%	15%	15%	28%	28%
Increase in juv. crime		110%	85%	221%	11%	236%
% of actual increase		43%	33%	85%	4%	91%

Note: The affected parameter in each model intervention is printed in bold.

facilities. In this case, following empirical results from the literature (Hutcherson, 2012; Fagan et al., 2013), the annual growth rate of crime-related skills in correctional facilities ranges from 34.8 percent at the lowest skill levels to 10.8 percent at the highest skill levels.

Whereas work-related skills remain constant if agents remain free, as long as the agents are apprehended they observe a reduction in their work-related skills due to the stigmatization effect η . In line with empirical evidence (Lott, 1990; Western, 2002; Joseph, 2003; Allgood et al., 2007), work-related skills decrease by 0.0225 units in the interval [1, 2] for the lowest quintile of work-related skills; depreciation accelerates by 0.0075 units for each successive quintile of work-related skills until reaching 0.0525 units for the highest quintile of work-related skills. In other words, the annual depreciation rate of work-related skills ranges from 8.7 percent at the lowest skill levels to 10.7 percent at the highest skill levels. This depreciation in work-related skills is only applicable for adults, as juvenile criminal records are sealed by law.

Data from Uruguay's national household survey suggests that the wage rate per unit of education (years of schooling) follows a lognormal distribution with mean very close to its standard deviation. Thus, I assume that the wage rate per unit of work-related skill is drawn from a lognormal distribution with mean and standard deviation \bar{w} .

Finally, I calibrate the only free parameter of the model, the ratio of the time-invariant mean wage per unit of work-related skill to the monetary gain per unit of crime-related skill \bar{w}/g , to reproduce the observed juvenile crime rate in Uruguay in 2001.

4. An incentive-compatible increase in juvenile crime

Criminal court records indicate that youth crime increased 260 percent between 2001 and 2010 (PJROU, 2001–2010).⁷ In 2010, minors' aged 13–17 comprised roughly 8 percent of the Uruguayan population but accounted for more than 40 percent of the total number of robberies (Bonomi, 2011).

To test the model's ability to reproduce the observed juvenile crime variation in Uruguay, I start by calibrating the model to match 2001 juvenile crime rates. I consider the five-year average values of the parameters for the period 1997–2001 in order to reflect the steady-state behavior of cohorts that were fully exposed to the environmental parameters during the relevant age range (from 13 to 17 years old). I then exogenously affect key model parameters to reflect the unexpected economic and institutional changes observed in Uruguay. I compute the model-predicted increase in juvenile crime and compare this prediction with the variation in juvenile crime observed between 2001 and 2010.⁸ Table 3 presents the results.

Both wages and per capita income fell dramatically during the 2002 economic and financial crisis in Uruguay and started to recover in 2004. Yet while in 2010 the five-year average real per capita income was 20 percent above its 2001 level, the five-year average real wage adjusted by unemployment was still 2 percent below its pre-crisis peak.^{9,10} This observed gap between adjusted wages and per capita income affects the individual return to crime insofar as monetary gains from

⁷ Actually, criminal court records indicate that youth crime increased 170 percent in 2010 relative to the levels observed in 2001 (PJROU, 2001–2010). However, since attempted-theft (one of the most prevalent forms of juvenile offending in Uruguay) was decriminalized in 2004, these records understate the real rise in juvenile crime. Before its decriminalization, 25 percent of all cases initiated by the juvenile justice system were attempted-thefts (Sayagués-Laso, 2004). The number of prosecutions between 2004 and 2010 is therefore adjusted by a factor of 4/3 to construct a consistent time series of juvenile offending.

⁸ Population growth over this period is near zero.

⁹ I compute real effective wages as real wages \cdot (1-unemployment rate) in order to recognize the evolution of unemployment in the Uruguayan economy over the relevant period. This model is unable to determine the effect of business cycle fluctuations on unemployment rates. Model predictions offer an upper bound to the effects of business cycle fluctuations on crime rates. For a given level of crime-related skills, a reduction in effective wages would push those agents with the lowest work-related skills to choose crime or school over work. If the reduction in effective wages were expected to be persistent in the long run, it would reduce not only the incentive to work but also the incentive to study. Therefore, some agents who in this model decide to commit crime or go to school would instead choose to be unemployed if they had the choice (had the model accounted for the opportunity cost of working or the utility derived from leisure).

¹⁰ A longer recovery time for wages than for per capita income after a financial crisis is consistent with empirical international macro literature (see Calvo et al., 2006).

crime per unit of crime-related skills increase hand in hand with per capita income. The assumption that the loot increases with income is frequent in the literature (Ehrlich, 1996). Moreover, empirical evidence from police records on the targets of property crime in Uruguay suggests a direct relationship between household wealth and the monetary value of the loot.¹¹ In other words, the financial rewards from criminal activities increased 22 percent more than the financial rewards from legal work. Therefore, when I affect the model parameter \bar{w}/g to reproduce the observed dynamics in per capita income and wages, the model predicts an increase in juvenile crime of 110 percent, which accounts for 43 percent of the total observed variation between 2001 and 2010 (see column (1) of Table 3).

The second factor I analyze is the approval of a lenient juvenile criminal code in 2004 (Law 17,823). Beyond several procedural changes, the new law decriminalized attempted-theft and established that judges should not consider aggravating circumstances in offenses committed by minors.¹² Under this new juvenile regulation, the average effective sentence length was reduced to 3 months (Lopez and Palummo, 2013). Additionally, the 2004 code gave judges the authority to arbitrarily decide whether to initiate a judicial procedure or not. In fact, judges decided to release 40 percent of the juveniles under suspicion (Sayagués-Laso, 2004). After adjusting the average effective sentence length (s_j) and the probability of apprehension (P_j) to reflect the new regulation, the model predicts an equilibrium increase in juvenile crime of 85 percent, which accounts for 33 percent of the total observed variation from 2001 to 2010 (see column (2) of Table 3).

When I combine this legal change with the observed differential evolution of the return to legal and criminal activities, the model predicts an increase in youth delinquency of 221 percent, accounting for 85 percent of the observed variation in juvenile offending (see column (3) of Table 3).

The third factor I consider to explain the evolution of juvenile delinquency in Uruguay is the increase in the escape rate from correctional facilities. According to government statistics (INAU, 2011), the five-year average probability of escape from detention centers (ε_j) rose from 15 percent in 2001 to 28 percent in 2010. After changing the escape probability in line with the evidence, the model predicts an equilibrium increase of 11 percent in the juvenile crime level, which accounts for 4 percent of the total observed variation over the period 2001–2010 (see column (4) of Table 3). Moreover, after considering the last three factors together, the model explains 91 percent of the juvenile crime increase observed in Uruguay (see column (5) of Table 3).

The model can also reproduce the evolution of the juvenile work rate and the school enrollment rate over the period 2001–2010. The model predicts a decrease of 10 percent in youth employment, a reduction very similar to the one observed between 2001 and 2010, according to data from the national household survey.¹³ At the same time, the model predicts a 9 percent decrease in youth school enrollment, whereas the national household survey shows a reduction of 3 percent over the same period.¹⁴ This overestimation is consistent with the fact that 20 percent of juvenile offenders also attend school (Lopez and Palummo, 2013).

Moreover, the calibrated model is also able to explain the evolution of adult crime between 2001 and 2010.¹⁵ The model predicts an increase of 101 percent in adult crime, close to the 90 percent increase in the number of criminal procedures initiated by the adult criminal justice system between 2001 and 2010 (PJROU, 2001–2010).

An additional potentially explanatory factor of higher juvenile crime is increased drug consumption. Official statistics indicate that paste cocaine seizures multiplied by 6.6 between 2003 and 2010, while total annual drug seizures remained unchanged (JND, 2013).¹⁶ More than 10 percent of the juvenile population from backgrounds with high social vulnerability frequently consumes paste cocaine (JND, 2007), and paste cocaine incidence among inmates in juvenile correctional facilities is 53 percent (JND, 2010). Becker and Mulligan (1997) developed a theoretical model in which drug addiction causes a rational increase in future discounting. Moreover, experimental studies show that drug consumption substantially increases discount rates (Bretteville-Jensen, 1999; Petry, 2003; Coffey et al., 2003; Kirby and Petry, 2004). In fact, if I exogenously reduce the value of parameter β from 0.986 to 0.982, recognizing drug consumer's lower capacity to project events into the future, the model matches the entire variation in juvenile crime.

To sum up, I virtually reproduce the evolution of juvenile delinquency in Uruguay between 2001 and 2010 by affecting only key model parameters to reflect observed changes. Thus, a model in which youths rationally respond to observed increases in the financial rewards from crime and to significant reductions in the expected punishment can explain the growth in juvenile crime in Uruguay. Model results suggest that the current juvenile crime rates in Uruguay are not so surprising after all. Economic and institutional factors are conducive to an environment where a significant fraction of the youth population finds it attractive to engage in criminal activities.

¹¹ According to police records on property crimes, seven types of goods describe 70 percent of all stolen property during the entire time period. 75 percent of these are comprised of electronics and appliances (22–24%), clothing and accessories (7–9%), jewelry (4–5%), cars (3–6%), bicycles (2–5%) and construction tools (3–4%). The pecuniary returns from crime associated with these categories are naturally assumed to move with per capita income. The remaining 25 percent of total stolen property is comprised of cash, which I also assumed to evolve along per capita income since there is no evidence of decreased use of cash in Uruguay. As a matter of fact, Uruguay's deposits to GDP and bank credit to GDP ratios barely changed between 2001 and 2010.

¹² Attempted-theft applies only to adult offenders who are in possession of stolen property when arrested.

¹³ The variation in youth employment is given by the change in $\int_w \sum_H \sum_B \sum_{t=0}^{t-1} J(w_t, H, B, t) W(w_t, H, B, t) dF(w_t)$.

¹⁴ The variation in youth school enrollment is given by the change in $\int_w \sum_H \sum_B \sum_{t=0}^{t-1} J(w_t, H, B, t) S(w_t, H, B, t) dF(w_t)$.

¹⁵ The variation in adult crime is given by the change in $\int_w \sum_H \sum_B \sum_{t=\tau}^T J(w_t, H, B, t) C(w_t, H, B, t) dF(w_t)$.

¹⁶ Paste cocaine acts as a cheap alternative to cocaine and is produced in the crude intermediate stages of cocaine processing.

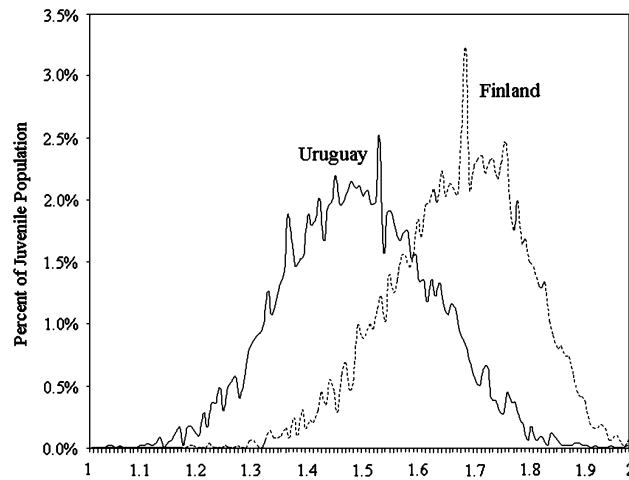


Fig. 1. Improvement of work-related skills.

5. The fight against juvenile crime

In this section, I use the calibrated and tested model to perform counterfactual exercises in order to compare the effectiveness of alternative policies in the fight against juvenile crime.

First, I adjust the initial parameterization to reproduce the 2010 situation in Uruguay. Both labor income and the monetary gains from crime have to reflect the observed gap in the evolution of wages and per capita income ($\bar{w}/g = 1.9/1.22$). For juveniles, the new probability of apprehension ($P_j = 6\%$), the new average effective sentence length ($s_j = 1$), and the new probability of escape ($\varepsilon_j = 28\%$) reflect a lower expected punishment for potential offenders. The discount factor ($\beta = 0.982$) is consistent with the paste cocaine incidence among juveniles in Uruguay. According to the national household survey, the distribution of wages per unit of work-related skill did not change between 2001 and 2010. The same is true for the initial distribution of work-related skills of the juvenile population, which I now estimate using the results of the 2009 PISA tests.

A consensus way of fighting juvenile delinquency is to increase the opportunity cost of crime through the improvement of work-related skills and wage rates. Several empirical studies confirm the negative relationship between education and crime (Cullen et al., 2003; Lochner and Moretti, 2004; Merlo and Wolpin, 2009; Berthelon and Kruger, 2011; Hjalmarsson and Lochner, 2012; Machin et al., 2012; Meghir et al., 2012). Accordingly, the model predicts that if Uruguayan youths had work-related skills equal to those observed in Finland (one of the world's leaders in youth academic performance according to PISA tests, see Fig. 1) and if the wage rate per unit of work-related skill recovered to its 2001 level relative to per capita income, juvenile crime would decline by 43 percent. Under this scenario, legal activities would become more attractive than crime for a large subset of youths. However, the 37-percentage point reduction in the share of low-achievers needed to converge with Finland would require a deep reform of the Uruguayan educational system.

Alternative policies aimed at reducing the net gains from crime by increasing expected punishment can also be considered within this framework. The results in the empirical literature are inconclusive. On the one hand, several criminological studies in the US find no evidence of deterrent effects (Singer and McDowall, 1988; Jensen and Metsger, 1994; Steiner et al., 2006). On the other hand, more recent literature from the US, Europe and Latin America finds that harsher punishments deter potential juvenile offenders (Levitt, 1998; Imai and Krishna, 2004; Mocan and Rees, 2005; Oka, 2009; Hjalmarsson, 2009; Entoff, 2011; Ibáñez et al., 2013).

An increase in the deterrent effect of punishment could be implemented by increasing the level of punishment, by increasing the certainty of punishment, or by reducing the escape rate from correctional facilities. All these measures can be analyzed under the framework developed in this paper. According to the calibrated model, if the average sentence length were doubled from one to two quarters (akin to returning to the pre-2004 law average sentence length), juvenile crime would decline by 19 percent. If the average sentence length were multiplied by 3 to converge with the adult average sentence length, juvenile crime would decline by 35 percent. Naturally, the larger the increase in the level of punishment, the higher the projected reduction in juvenile crime will be. Alternatively, if the probability of apprehension increased from 6 percent to 10 percent (akin to returning to the pre-2004 law probability of apprehension and converging to adult standards), juvenile crime would decline by 9 percent. Finally, the reduction in juvenile crime expected from the complete elimination of escapes from correctional facilities is 5 percent.

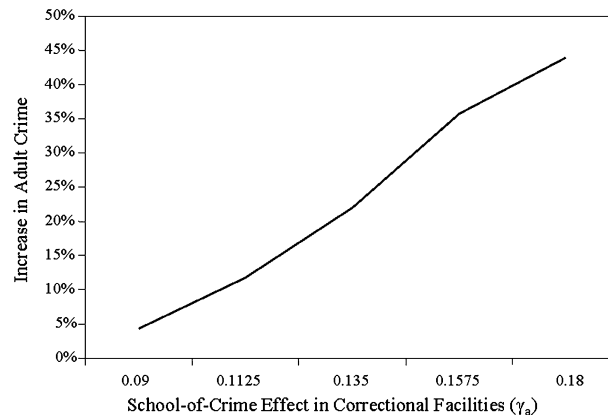
A more complex policy that combines all the previous measures would be a reduction of the age of criminal responsibility (see Table 4). In this case, offenders aged 16 and 17 would be judged in adult courts by adult standards of legal responsibility. Therefore, for this subset of youths, the average sentence length would increase from one to three quarters, the probability of apprehension would climb from 6 to 10 percent, and the escape probability would fall from 28 percent to zero. Under this scenario, the expected reduction in juvenile crime is 51 percent.

Table 4

Reduction in the age of criminal majority.

Model parameter	13–15 ys		16–17 ys	
	Baseline	Policy	Baseline	Policy
P_j	6%	6%	6%	10%
s_j	1Q	1Q	1Q	3Q
ε_j	28%	28%	28%	0%

Note: The affected parameter is printed in bold.

**Fig. 2.** School-of-crime effect and adult crime.

However, since harsher punishment to juveniles can increase future adult crime, the cure could prove to be worse than the disease. In fact, if the school-of-crime effect were strong enough in adult detention centers, the model suggests that lowering the age of criminal majority would increase the likelihood of criminal involvement upon reaching adulthood.¹⁷ The calibrated model suggests that the acceleration in the transmission of crime-related skills generates incentives for future criminal involvement. Moreover, it predicts that the stronger the school-of-crime effect is, the higher the increase in future adult crime (see Fig. 2). This result is consistent with the empirical literature that suggests that trying and sentencing juvenile offenders as adults increases the likelihood of recidivism (Podkopacz and Feld, 1995; Bishop et al., 1996; Fagan, 1996; Myers, 2003).

6. Conclusions and discussion

Psychological literature has long recognized that psychosocial maturation proceeds more slowly than cognitive development and that age differences in judgment reflect social and emotional differences between adolescents and adults. These differences are exacerbated in aspects such as susceptibility to peer influence, reward sensitivity, and the capacity for self-regulation (Steinberg, 2009). However, a rational model of behavior that considers the consistent decisions of forward-looking youths and incorporates significant changes in the incentives for crime observed in Uruguay is able to explain the recent juvenile crime spike.

Model results suggest that lowering the age of criminal majority is an effective measure to reduce juvenile crime. However, if the transmission of crime-related skills through the school-of-crime effect in correctional facilities were strong enough, longer sentences increase could future crime rates. This result is in line with Aizer and Doyle (2013), which find that being convicted as a minor increases the probability of subsequent incarceration by 22 percentage points.

It thus becomes critical to minimize the school-of-crime effect in correctional facilities. Longer sentences are consistent with a reduction in the likelihood of recidivism after release only if incarceration enhances work-related skills and minimizes the transmission of crime-related skills. However, much work remains to be done in order to truly understand the rehabilitation process of juvenile offenders. Measures such as electronic monitoring bracelets should be considered as alternatives to incarceration. Under this system, which might reduce recidivism by up to 40 percent according to Di Tella and Schargrodsky (2013), correctional facilities employees verify whether the juveniles are violating a set of pre-established conditions, such as attending school and going to work.

¹⁷ To compute the variation in adult crime, I consider the expected behavior of current youths at early adulthood (18–27 years old) according to the following formula: $\int_w \sum_H \sum_B \sum_{t=\tau}^{\tau+10} J(w_t, H, B, t) C(w_t, H, B, t) dF(w_t)$.

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