The Juvenile Crime Dilemma

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Abstract

I develop a dynamic model of behavior to analyze juvenile crime. The consistent decisions between crime and legal activities of forward-looking youths depend upon their work- and criminal-specific human capital, which in turn are 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 crime levels, as economic and legal factors change over time. The model is able to reproduce virtually all the recent increase in juvenile crime by affecting key model parameters in line with observed facts. Additional counterfactual results suggest an increase in the expected punishments of young offenders within the juvenile justice system is a better way to fight juvenile crime than the reduction of the age of criminal responsability.

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I. INTRODUCTION

Juvenile delinquency is at the forefront of social challenges worldwide. This concern cuts across economic development categories and geographical regions as youth crime rates are rising in virtually every part of the world (United Nations 2003).[1] The delicate intersection between childhood and criminality creates a complex dilemma to deal with. Social scientists, activists, and legislators are all debating both its causes and potential solutions.

The literature has found several determinants of juvenile criminal involvement.[2] Biological factors, such as being male, having low intelligence and short time horizons, 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. Since Becker (1968), juvenile delinquency can also be thought of as a rational response to the incentives for legal and criminal activities. Thus, 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 minors are considered as delinquent acts within a separate justice system, designed to recognize the special needs and immature status of adolescents while emphasizing rehabilitation over punishment. Juvenile criminal records are sealed from adult courts, arrested youths are judged by juvenile courts and once convicted are strictly segregated from adults in custody. Psychological research supports this dual treatment based on the psychosocial 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 also raise relevant issues of intertemporal choice and have ambiguous effects on the incentives for youth criminal involvement. The negative signal generated by court records, which ruins future wages, or the acquisition of criminal-specific human capital in detention centers 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 a framework where youths choose between crime and legal activities, and in which their work and crime related skills depend upon both their current as well as past choices. In this model, youths are forward-looking and so recognize their present choices affect their future skills and income. This path dependence incorporates individual heterogeneity since agents with different records face external incentives to commit crime in different ways and thus exhibit very different behavior.

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

[1] Juvenile offending covers a multitude of different violations of legal and social norms, ranging from minor offences to serious crimes committed by young people. The focus here is exclusively serious juvenile crime.

[2] See Levitt and Lochner (2000).

majority (the age at which individuals become subject to adult courts). The probability of convition, the level of punishment, and the probability of escape from correctional facilities all vary depending on the individual's juvenile status.

This analysis 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). Previous dynamic models of crime develop different frameworks from the model presented in this paper (Flinn 1986; Imrohoroglu et al. 2004; Burdett et al. 2003; Burdett et al. 2004; Huang et al. 2004; Lochner 2004; Sickles and Williams 2008; 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 previous theoretical models specifically designed to deal with the transition from juvenile to adult crime.

Substantial changes in juvenile crime incentives make Uruguay an ideal environment to calibrate and test this model. The recent dynamics of wages and household wealth have led to financial rewards from criminal activities exceeding returns in the job market. Additionally, the introduction of a more lenient juvenile crime regulation and control substantially lowered the expected cost of crime. At the same time, juvenile crime almost tripled between 1997 and 2010. This massive spike in youth delinquency has triggered a strong debate over the threshold age of criminal responsibility. In fact, in 2014 Uruguayans will vote on whether to reform the Constitution in order to reduce the age of criminal majority from 18 to 16 years of age.

The calibrated model is able to reproduce virtually all the recent increase in juvenile crime in Uruguay by affecting key model parameters in line with observed facts. According to the model, the anemic evolution of the return of legal activities relative to the monetary gains from crime explains 35 percent of the variation in juvenile delinquency from 1997 to 2010. Additionally, a softer juvenile crime regulation approved in 2004, which includes the decriminalization of attempted-theft, plays a key role by explaining 38 percent of the observed variation. The significant increase in escapes from juvenile correctional facilities explains an extra 13 percent of the actual increase in juvenile crime. Finally, the interaction of all the aforementioned facts with a reduction in the time horizons of youths derived from a cocaine paste epidemic explains the observed spike in juvenile delinquency in Uruguay.

This result is consistent with the empirical literature suggesting that harsher punishments deter potential juvenile offenders (Levitt 1998; Imai and Krishna 2004; Mocan and Rees 2005; Oka 2009; Hjalmarsson 2009; Entoff 2011) and contradicts previous studies that find no evidence of such deterrence effects (Singer and McDowall 1988; Jensen and Metsger 1994; Steiner et al. 2006).

The model further provides a framework to quantify the effectiveness of alternative measures in the fight against juvenile crime. Counterfactual model results predict a reduction in the age of majority from 18 to 16 years old would reduce juvenile delinquency by 35 percent due to the deterrent effects of harsher punishments. Alternatively, a harsher legal redefinition of juvenile offenses and the elimination of escapes from correctional facilities would not only reduce juvenile crime involvement by a similar magnitude but

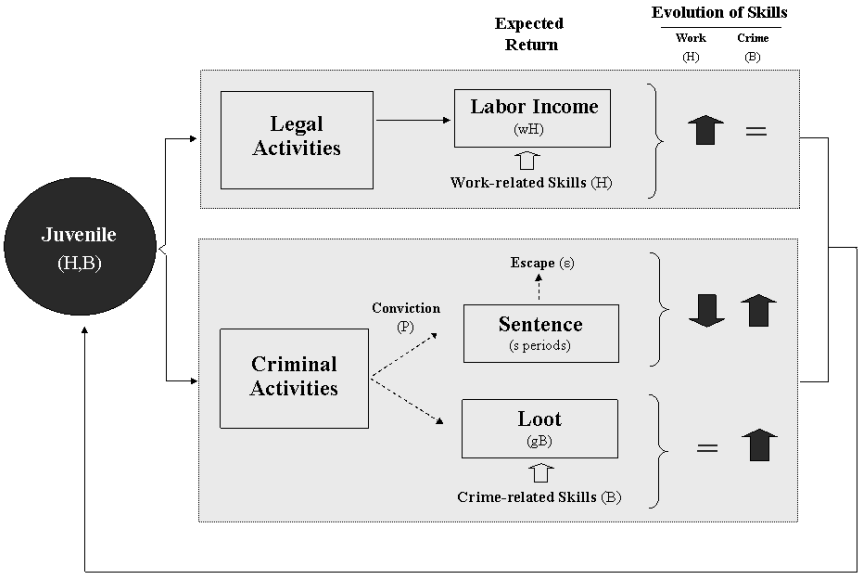
also would minimize the likelihood of criminal involvement later in life, once juveniles become adults. Thus, special care should be taken to segregate new inmates from experienced youth offenders in custody. If the school-of-crime effect (according to which inmates learn criminal skills in jail) were strong enough, the cure could prove to be worse than the disease, as the model predicts a harsher punishment could even increase crime rates.

The remainder of the paper is organized as follows. Section II presents the model. Section III calibrates the model for Uruguay and section IV tests its ability to explain the recent juvenile crime spike. Section V discusses alternative measures to fight juvenile crime. Section VI concludes.

II. 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 conditioned 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 both legal and criminal opportunities and choose between working or committing crimes. Agents are endowed with two different types of human capital, work-related skills H and crime-related skills B, which evolve based upon their choices. Figure 1 depicts the basic idea of this model of behavior.

Figure 1. The Model.



If the agents decide to work, they accept one independent wage rate per unit of work-related skill w drawn from the time invariant distribution $F(w) = \Pr(w_t \leq w)$. Earnings in the period are the product of the wage rate offered and the agent's level of work-related skills. Working agents are then free to choose between work or crime on 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, which includes pre-trial detention time. Income is nil for the duration of the sentence, and once released agents are able to choose again between work and crime. Individuals are able to escape from detention centers with probability ε. Agents who escape from the correctional facility also receive zero income in the current period and are free to choose between work or crime on the following period. 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 their level of crime-related skills. Those agents are then free to choose between work or crime on the following period.

In all the cases, the continuation value next period depends on whether the agents are in jail or free, and on how their work-related skills and crime-related skills evolved from the previous period.

Key factors affecting individual decisions are significantly different before and after the age of majority τ. The probability of apprehension, the punishment once caught and the probability of escape all vary with the individual's juvenile status.

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:

$$V(w_t, H_t, B_t, t) = \max_{\text{Work, Crime}} \left\{ \begin{array}{c} w_t H_t + \beta E_t V(w_{t+1}, H_{t+1}, B_{t+1}, t+1), \\ P_i \left(1-\varepsilon_i\right) \left[\beta^{s_i} E_t V\left(w_{t+s_i}, H_{t+s_i}, B_{t+s_i}, t+s_i\right)\right] \\ + P_i \varepsilon_i \beta E_t V\left(w_{t+1}, H_{t+1}, B_{t+1}, t+1\right) \\ + \left(1-P_i\right) \left[g B_t + \beta E_t V\left(w_{t+1}, H_{t+1}, B_{t+1}, t+1\right)\right] \end{array} \right\} \tag{1}$$

$$\text{where } i = \left\{ \begin{array}{l} j \text{ (juvenile) for } t \text{ such that } 0 \leq t < \tau \\ a \text{ (adult) for } t \text{ such that } \tau \leq t \leq T \end{array} \right.$$

There are a finite number of both skill levels whose dynamics depend upon the agent's choice. Table 1 depicts the laws of motion of state variables H_t and B_t. Work-related skills increase for individuals deciding to work due to on-the-job-training, leaving their level of crime-related skills unchanged. Agents deciding to engage in criminal activities who, after getting caught, serve the full sentence imposed by the judge see their work-related skills depreciate due to their criminal records and their crime-related skills increase due to both on-the-crime-training and the school-of-crime effect of conviction. Those individuals who manage to escape from the detention centers before serving their full sentence also face depreciation in their work-related skills and an increase in their crime-related skills through on-the-crime-training. Finally, agents who commit crime

but remain free maintain the same level of work-related skills and observe an increase in their crime-related skills through on-the-crime-training.

Table 1. Law of Motion of Skills.

	$H_{t+1} =$	$B_{t+1} =$
Work	$H_t + \alpha_i$ with $\alpha_i > 0$	B_t
Crime + Sentence	$H_t - \eta_i$ with $\eta_i > 0$	$B_t + \gamma_i$ with $\gamma_i > 0$
Crime + Escape	$H_t - \eta_i$ with $\eta_i > 0$	$B_t + \chi_i$ with $\chi_i > 0$
Crime + Free	H_t	$B_t + \chi_i$ with $\chi_i > 0$

This endogenous evolution of skills recognizes both the stigmatization and the school-of-crime effects of incarceration. The stigmatization effect refers to the fact that ex-offenders' earnings are low, even after controlling for their weak labor market characteristics (Western 2002; Holzer 2007, Pager et al. 2008). Incarceration erodes job skills and a criminal record signals to employers a potential employee might be untrustworthy. The belief that prisons are schools of crime also has widespread support. Empirical evidence suggests that confinement has negative consequences on future criminal behavior due to peer effects (Chen and Shapiro 2007; Camp and Gaes 2009). The intensity of both effects is different for juveniles and adults since juvenile 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:

$$V(w_t, H_t, B_t, t) = \max_{\text{work, crime}} \left\{ \begin{array}{c} w_t H_t + \beta \int_{w_{t+1}} V(w_{t+1}, H_t + \alpha_i, B_t, t+1) dF(w_{t+1}), \\ P_i (1-\varepsilon_i) \left[\beta^{s_i} \int_{w_{t+s_i}} V(w_{t+s_i}, H_{t-s_i} - s_i\eta_i, B_{t-s_i} + s_i\gamma_i, t+s_i) dF(w_{t+s_i}) \right] \\ + P_i \varepsilon_i \left[\beta \int_{w_{t+1}} V(w_{t+1}, H_t - \eta_i, B_t + \chi_i, t+1) dF(w_{t+1}) \right] \\ + (1-P_i) \left[gB_t + \beta \int_{w_{t+1}} V(w_{t+1}, H_t, B_t + \chi_i, t+1) dF(w_{t+1}) \right] \end{array} \right\} \tag{2}$$

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

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

Let $C(w_t, H, B, t) = 1$ if the agents in state (w_t, H, B, t) commit crime and let $C(w_t, H, B, t) = 0$ otherwise. Then, $J(w_t, H, B, t)$ is the number of free juveniles 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:

$$
\begin{aligned}
J\left(w_t, H, B, t\right) \quad = \quad & \left[1 - C\left(w_{t-1}, H - \alpha_j, B, t-1\right)\right] J\left(w_{t-1}, H - \alpha_j, B, t-1\right) \\
& + \left[\begin{array}{c} P_j \left(1 - \varepsilon_j\right) C\left(w_{t-1-s_j}, H + s_j\eta_j, B - s_j\gamma_j, t - s_j\right) \\ J\left(w_{t-1-s_j}, H + s_j\eta_j, B - s_j\gamma_j, t - s_j\right) \end{array} \right] \\
& + P_j\varepsilon_j C\left(w_{t-1}, H + \eta_j, B - \chi_j, t-1\right) J\left(w_{t-1}, H + \eta_j, B - \chi_j, t-1\right) \\
& + \left(1 - P_j\right) C\left(w_{t-1}, H, B - \chi_j, t-1\right) J\left(w_{t-1}, H, B - \chi_j, t-1\right) \qquad (3)
\end{aligned}
$$

The first addend on the right hand side of the Eq. (3) 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 second addend represents those convicted juveniles with work-related skills $H + s_j\eta_j$, 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 according to their sentence length. The third addend represents those youths with work-related skills $H + \eta_j$ 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 addend 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 avoided getting caught by the police.

Therefore, the total number of minors that commit crime is given by:

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

Eq. (4) gives the total number of individuals aged 13-17, endowed with every possible combination of work- and crime-related skills, that decide to commit crime after averaging the realizations of the wage rate per unit of work-related skill.

III. CALIBRATION

In this section I calibrate the model to fit the juvenile crime rates observed in Uruguay in 1997, before the beginning of the economic crisis and the introduction of relevant changes to the juvenile crime laws.

Each time period is a quarter and agents live for 200 quarters, or 50 years. I fix the discount factor β to 0.986, or just under 6 percent annually. Because the decisions makers are youths, this shorter than usual time horizon is consistent with the evidence that concern about the future and ability to plan ahead increase across the lifespan (Nurmi 1991; Green et al. 1994; Green et al. 1996; Green et al. 1999; Steinberg et al. 2009).

Table 2 depicts estimates of the key security parameters before and after the age of majority, applicable to Uruguay in 1997.

Table 2. Public Security Parameters (1997).

	Parameter	Juveniles ($i = j$)	Adults ($i = a$)
P_i	Probability of Conviction	10%	10%
s_i	Average Sentence Length	$2Q$	$5Q$
ε_i	Probability of Escape	11%	0

I estimate the probability of conviction as the ratio of total convictions to total offenses after adjusting data on police-recorded offenses for an underreporting rate of 50 percent.[3] This probability is 10 percent for both juveniles and adults. I compute the average adult sentence length of 5 quarters using the complete distribution of the effective duration of the prison spell of a representative sample of the Uruguayan prison population.[4] Judicial archives indicate that the effective average sentence length for juveniles was about 2 quarters in 1997. I define the probability of escape as the ratio between the number of prison breaks and the total number of inmates, which differs significantly before and after the age of majority. According to official statistics, this probability was 0.4 percent for adults and 11 percent for youths.

I set 135 different skill levels evenly partitioning the interval $[1, 2]$. Someone who starts out working with the lowest skill level will reach the highest level after 25 years, conditional on working in every period. I estimate the initial distribution of work-related skills through the results of the 2003 OECD Programme for International Student Assessment (PISA).[5] By design, PISA test scores reflect job market aptitude for a representative sample of youths. Due to lack of information, I assume a uniform distribution of crime-related skills.[6]

The annual variation in both skill levels is set in Table 3. If the individuals decide to work, their work-related skills increase by 0.0075 units in the interval $[1, 2]$. Put differently, the annual growth rate of work-related skills ranges from 3.2 percent at the lowest skill levels to 1.6 at the highest skill levels, 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 remain constant. If the agents commit crime and remain free, their crime-related skills increase due to on-the-crime-training by 0.0075 units in the interval $[1, 2]$. Due to lack of empirical evidence, I assume the same growth rate of skills for both work-related skills and crime-related skills. Agents who have reached the highest crime-related-skill levels retain those skills until working again. Work-related skills remain constant. The impact on skills is significantly different

[3] The underreporting rate, which is in line with the rate estimated for the U.S. (Levitt 1996) and for Chile (Nuñez at al. 2003), comes from official victimization surveys (Universidad de la República 2011).

[4] I consider the data of the complete history of entries and exits from penitentiary center ComCar (Complejo Carcelario Santiago Vázquez) since 2002. According to Prisoner Ombudsman Alvaro Garcé, inmates in ComCar (35 percent of the prison population) are a representative sample of urban Uruguayan offenders.

[5] The first participation of Uruguay in PISA was in 2003.

[6] Considering potential learning of crime-related skills at home, I assume that the initial distribution of crime-related skills follows the results of PISA test scores. I then reproduce sections IV and V without substantial changes (results available upon request) .

for adults and juveniles if the police apprehends them. If the agents are apprehended but manage to escape, the reduction in work-related skills is five times worse for adults than for juveniles, since the stigmatization effect is higher after reaching the age of majority (Allgood et al. 2003). The impact on crime-related skills is the same for both adults and juveniles due to similar on-the-crime-training effects. Finally, if agents are apprehended after crime and serve the full sentence, I assume the reduction in work-related skills and the increase in crime-related skills are five times higher in the case of adults. In this case, not only is the stigmatization effect higher for juveniles, but also the school-of-crime effect is stronger with more experienced teachers in adult jails.[7]

Table 3. Skill Parameters.

	Work-Related Skills (H)			Crime-Related Skills (B)		
	Parameter	Juveniles	Adults	Parameter	Juveniles	Adults
Work	α_i	0.0075	0.0075	–	–	–
Crime + Sentece	η_i	0.0075	0.0375	γ_i	0.0075	0.0375
Crime + Escape	η_i	0.0075	0.0375	χ_i	0.0075	0.0075
Crime + Free	–	–	–	χ_i	0.0075	0.0075

Data from the national household survey of Uruguay suggests the wage rate per unit of education (years of schooling) follows a lognormal distribution with a mean very close to the 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 $\overline{w}$.

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 $\overline{w}/g$, to reproduce the observed juvenile crime rate in Uruguay in 1997.

IV. AN INCENTIVE-COMPATIBLE INCREASE IN JUVENILE CRIME

Juvenile crime rates have risen at a striking rate over the past fifteen years in Uruguay. Between 1995 and 2006, the number of robberies committed by juveniles increased almost three times more than that for those committed by adults. In 2010, minors aged 13-17 comprised roughly 8 percent of the overall population, but accounted for 26 percent of the homicides and more than 40 percent of the total number of robberies (Bonomi 2011). Criminal court records indicate that youth crime increased 180 percent between 1997 and 2010 (Poder Judicial 1999-2010).[8]

[7] For robusteness, I let η_j and γ_j to take values in the interval $[0.015, 0.075]$ without major changes in the results of Sections IV and V.

[8] Raw data from criminal court records indicate that youth crime increased 110 percent in 2010 relative to the levels observed in 1997 (Poder Judicial 1999-2010). However, these records understate the rise in juvenile crime as attempted-theft (one of

To test the model's ability to reproduce actual juvenile crime variation in Uruguay, I start with the model calibrated to match 1997 juvenile crime rates. I then exogenously affect key model parameters in order to reflect the economic and institutional changes observed in Uruguay. The low increase in wages relative to the increase in monetary gains from crime, the introduction of a lenient juvenile crime regulation, the increase in the breakout rate from correctional facilities, and the cocaine paste epidemic are all relevant factors to analyze. For each factor, I compute the model predicted increase in juvenile crime (consistent with the changes observed in Uruguay), and compare these model predictions with the actual change observed between 1997 and 2010. Table 4 presents the results.

Table 4. Factors Affecting Juvenile Crime's Dynamics.

		(1)	(2)	(3)	(4)	(5)	(6)
Parameter	Baseline	Wages/Loot	Juv. Code	(1) + (2)	Breakouts	(3) + (4)	(5) + Drugs
$\overline{w}/g$	1.4	**1.4/1.2**	1.4	**1.4/1.2**	1.4	**1.4/1.2**	**1.4/1.2**
P_j	10%	10%	**6**%	**6**%	10%	**6**%	**6**%
s_j	2	2	**1**	**1**	2	**1**	**1**
ε_j	11%	11%	11%	11%	**38**%	**38**%	**38**%
β	0.986	0.986	0.986	0.986	0.986	0.986	**0.95**
Increase in Juv. Crime		63%	69%	118%	21%	136%	180%
% of Actual Increase		35%	38%	65%	13%	75%	100%

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

Both wages and total per capita income fell dramatically during the 1998-2002 economic crisis in Uruguay and in 2003 both started to rise. However, while in 2010 real per capita income was 34 percent above its 1997 level, real wages were only 12 percent above pre-crisis peak. This observed gap between wages and per capita income affects the individual return to crime as long as monetary gains from 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) and in line with the empirical evidence from police records on property crime in Uruguay.[9] In other words, the financial rewards from criminal activities increased 20 percent more than the financial rewards from legal work. Therefore, when I affect the model parameter

the most common types of juvenile offense in Uruguay) was decriminalized in the juvenile crime code passed in 2004. Before the introduction of this new regulation, attempted-theft represented 25 percent of the total number of trials initiated by the juvenile justice system (Sayagués-Laso 2004 and 2010). I thus adjust the number of procedures initiated by the juvenile justice system between 2004 and 2010 by a factor of 4/3 to provide a consistent time series of juvenile offending that accounts for attempted-thefts.

[9] According to police records on property crimes, seven categories comprise 70 percent of all stolen property in a quite stable pattern for the analyzed time period. Among these categories, 75 percent is represented by 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 money, which I also assumed to evolve along per capita income since there is

$\overline{w}/g$ to reproduce the observed dynamics in per capita income and wages, the model predicts an increase in juvenile crime of 63 percent, which accounts for 35 percent of the total observed variation (see column (1) of Table 4).

The calibrated model is also able to reproduce the evolution of adult crime over the same period after the adjustment in $\overline{w}/g$.[10] The model predicts an increase of 113 percent in adult crime whereas the number of criminal procedures (per 100,000 adults) initiated by the adult criminal justice system increased by 108 between 1997 and 2010 (Poder Judicial 1999-2010). Predictions on adult crime provide an out-of-sample test for the model, as it was not initially calibrated to match adult crime.

The second factor I examine is the approval of a lenient juvenile criminal code (Law 17,823) in 2004. Beyond several changes in procedures dealing with juveniles, the new code decriminalized attempted-theft and established that judges should not consider aggravating circumstances in offenses committed by minors.[11] According to the Supreme Court of Justice, juveniles are usually punished with sentences that are 1/6 of those applicable to adults for the same type of offense. Therefore, this new juvenile regulation implied a reduction by about 50 percent in the average sentence length. Additionally, the 2004 code allowed judges to arbitrarily decide whether to even initiate a judicial procedure. In fact, during the first year under the new code, judges decided to release 40 percent of the juveniles under suspicion (Sayagués-Laso 2004). After modifying the average sentence length s_j and the probability of apprehension P_j consistently with the new code, the model predicts an equilibrium increase in juvenile crime of 69 percent relative to 1997, which accounts for 38 percent of the total observed variation (see column (2) of Table 4).

When I combine this legal modification with the observed differential evolution of the return of legal and criminal activities, the model predicts an increase in youth delinquency of 118 percent, accounting for 65 percent of the observed variation in juvenile offending (see column (3) of Table 4).

The third factor I consider to explain the evolution of juvenile delinquency in Uruguay is the rise in the escape rate from correctional facilities. According to official statistics, the probability of escape from detention centers (ratio of the number of escapes to the number of inmates in juvenile correctional facilities) ε_j jumped from 11 percent in 1997 to 38 percent in 2010. After changing the escape probability in line with the evidence, the model predicts an equilibrium increase of 21 percent in juvenile crime relative to 1997 and accounts for 13 percent of the total observed variation (see column (4) of Table 4). Moreover, after considering the last three factors together, the model explains 75 percent of the juvenile crime increase observed in Uruguay (see column (5) of Table 4).

Finally, I introduce the paste cocaine epidemic into the analysis. The incidence of paste cocaine among

no evidence of significant deepening bancarization (decreased use of cash) in Uruguay. As a matter of fact, Uruguayans' bank deposits over GDP and bank credit over GDP in 2010 were nearly identical to those observed in 1997.

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

[11] Attempted-theft applies when offenders are arrested in the act of theft or right after committing theft while still in possession of the stolen property, and is defined as a crime for adults.

youths has skyrocketed in Uruguay since 2003. Official statistics indicate that paste cocaine seizures multiplied by 6.8 between 2003 and 2010, while total annual drug seizures multiplied by only 1.5 (Junta Nacional de Drogas 2010a). In fact, 10 percent of the juvenile population from backgrounds with high social vulnerability frequently consumes paste cocaine (Junta Nacional de Drogas 2007) and paste cocaine incidence among inmates in juvenile correctional facilities is 53 percent (Junta Nacional de Drogas 2010b). 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 subtantially increases discount rates (Bretteville-Jensen 1999; Petry 2003; Coffey et al. 2003; Kirby and Petry 2004). Therefore, in order to match the entire variation in juvenile crime it is enough to exogenously reduce the value of parameter beta from 0.986 to 0.950, recognizing youth's lower capacity to project events into the future under the effect of the drugs. If we consider all factors together: the evolution of the return to legal activities below monetary gains from crime, the lenient juvenile crime regulation, the escapes from correctional facilities and the paste cocaine epidemic, I am able to explain all the variation in youth delinquency (see column (6) of Table 4).

To sum up, I virtually reproduce the evolution of juvenile delinquency in Uruguay from 1997 to 2010 by affecting only key model parameters according to 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 is at the margin of choosing whether or not to engage in criminal activities. In the same vein, it should come as no surprise either that records on judicial interviews with adolescents reveal that more than 50 percent of youths involved in criminal activities in Uruguay report delinquency as their professional activity (Sayagués-Laso 2010).

V. THE FIGHT AGAINST JUVENILE CRIME

In this section, I use the already calibrated and tested model to perform counterfactual exercises to discuss 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 ($\overline{w}/g = 1.4/1.2$). For juveniles, the new probability of effective apprehension ($P_j = 6\%$), the new average sentence length ($\overline{s}_j = 1$) and the new probability of escape ($\varepsilon_j = 38\%$) have to reflect a more lenient expected punishment for potential offenders. The discount factor ($\beta = 0.95$) has to be 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 in 2010 mirrors the pattern observed in the 1997 calibration. 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 by increasing the opportunity cost of crime through the improvement of work-related skills and wage rates. In fact, recent empirical literature strongly supports the existence of a negative relationship between education and crime (Machin et al. 2012; Meghir et al. 2012). In this line, the model predicts that if Uruguayan youths had the work-related skills observed in Finland (one of the world's leaders in youth academic performance according to the PISA tests) and if the wage rate per unit of work-related skill recovered its relative levels with respect to per capita income observed in 1997, juvenile crime would decline by 50 percent. Under this scenario, legal activities would become more attractive than crime for a large set of Uruguayan youths. However, a significant reduction in the number of juveniles without the minimum requirements for productive insertion into the labor market would require a deep reform in the Uruguayan educational system. 2009 PISA results indicate educational failure should be reduced from the current 44 percent to the 7 percent observed in Finland.

Alternative policies aimed at reducing the gains from crime by increasing the potential punishment facing youths should thus be considered. I first evaluate the effects of partially eliminating the separate juvenile justice system, treating some adolescents by adult standards of criminal culpability and punishment. The reduction of the age of criminal majority implies that adult security parameters as well as adult levels of stigmatization and school-of-crime effects apply to those juveniles aged 16-17 (see Table 5). If those aged 16-17 face a probability of apprehension of 10 percent instead of 6 percent, an average sentence length of 5 quarters instead of 1 quarter and a zero probability of escape from detention centers instead of 38 percent, the model predicts a 35 percent reduction in youth delinquency. The deterrence argument that states that harsh punishments reduce criminal involvement holds once the age of majority is reduced.

Table 5. Increase in the Expected Punishment of Juveniles.

	Reduction in the Age of Criminal Majority				Harsher Juvenile System	
Model	13-15 ys		16-17 ys		13-17 ys	
Parameter	Baseline	Policy	Baseline	Policy	Baseline	Policy
P_j	6%	6%	6%	**10%**	6%	**10%**
s_j	$1Q$	$1Q$	$1Q$	**5Q**	$1Q$	**2Q**
ε_j	38%	38%	38%	**0%**	38%	**0%**
η_j	0.0075	0.0075	0.0075	**0.0375**	0.0075	0.0075
γ_j	0.0075	0.0075	0.0075	**0.0375**	0.0075	0.0075

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

I alternatively evaluate measures that would entail harsher expected punishment for juveniles but would maintain the trying of minors in juvenile courts (see Table 5). This policy implies the complete elimination of escapes from youth detention centers due to tighter security measures, and includes a legal redefinition that

increases the average sentence length from 1 quarter to 2 quarters and the effective probability of apprehension from 6 percent to 10 percent (the levels observed before the 2004 juvenile crime code). According to model estimates, this harsher juvenile crime system would reduce youth crime by 36 percent.

Both the reduction of the age of majority and the increase in the expected punishment within the juvenile system predict a similar reduction in youth crime. However, model results suggest opposite effects on criminal involvement once current juveniles become adults.[12] While the increase in the expected level of punishment within the juvenile system reduces future adult crime by 10 percent, an early transition to adult courts increases the incentives for crime later in life increasing adult crime by 5 percent. The stigmatizing treatment in adult courts coupled with the acceleration in the transmission of crime-related skills in adult detention facilities offset the deterrent effect brought about by the harsher punishment, generating incentives for future criminal involvement. Empirical evidence suggests that the social environment of correctional centers is criminogenic due to peer influence (Bayer at al. 2009; DeLisi et al. 2011). This result is consistent with the empirical evidence that suggest trying and sentencing juvenile offenders as adults increases the likelihood of recidivism (Podkopacz and Feld 1995; Bishop et al. 1996; Fagan 1996; Myers 2003).

VI. CONCLUSIONS

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, future orientation, reward sensitivity, and the capacity for self-regulation (Steinberg 2009). However, a rational model of youth behavior that consider the consistent decisions of forward-looking youths is able to explain the recent juvenile crime spike in Uruguay.

Model results suggest that an increase in the expected punishments of young offenders in the juvenile justice system is a better way to fight juvenile crime than an early transition to adult crime courts. The first policy not only predicts a similar reduction in juvenile offending but also avoids negative consequences in terms of adult criminal involvement. This result is consistent with the literature that suggests a U-shaped relationship between severity of punishment and future criminal behavior, with an optimal level of punishment minimizing the likelihood of recidivism (Pinchler and Romer 2011). Harsher punishments would reduce recidivism if the levels of punishments are relatively low, and harshness would increase recidivism if punishments are relatively high. Thus, the optimal level of punishment should deter offenders and minimize re-offense by facilitating future reintroduction into the formal economy. The model calibrated for Uruguay suggests that the increase in the expected punishment within the juvenile system seems to be on the downward side of this U, whereas the reduction of the age of majority is on the upward side.

[12] 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 $\int_w \sum_H \sum_B \sum_{t=\tau}^{\tau+10} J(w_t, H, B, t)\, C(w_t, H, B, t)\, dF(w_t)$.

The introduction of harsher punishments should avoid an increase in the school-of-crime effects of confinement. Model results suggest that if the increase in crime-related skill in correctional facilities were strong enough, longer sentences could increase crime rates. Rehabilitation in correctional facilities could be consistent with a longer sentence only if it enhances work-related skills. Alternative measures such as the introduction of electronic monitoring bracelets for juveniles should thus be considered. Under this system, which might reduce recidivism by up to 40 percent according to Di Tella and Schargrodsky (2009), correctional facilities employees verify whether the juveniles are violating a set of pre-established conditions, such as attending school and work. However, much work remains to be done to deeply understand the rehabilitation process of youth offenders.

REFERENCES

[1] Allgood, S., D. Mustard, D., and Warren, R., 2007. The impact of youth criminal behavior on adult earnings. The University of Georgia Manuscript.

[2] Bayer, P., Hjalmarsson, R., and Pozen D., 2009. Building criminal capital behind bars: Peer effects in juvenile corrections. Quarterly Journal of Economics 124(1), 105-147.

[3] Becker, G., 1968. Crime and punishment: An economic approach. Journal of Political Economy 76(2), 169-217.

[4] Becker, G., and Mulligan C., 1997. The endogenous determination of time preference. Quarterly Journal of Economics 112(3), 729-758.

[5] Bishop, D., Frazier, C., Lanza-Kaduce, L., and Winner, L., 1996. The transfer of juveniles to criminal court: Does it make a difference?. Crime and Delinquency 42, 171-191.

[6] Block, M., and Gerety, V., 1995. Some experimental evidence on differences between student and prisoner reactions to monetary penalies and risk. Journal of Legal Studies 24(1), 123-138.

[7] Block, M., and Heineke, M., 1975. A labor theoretic analysis of the criminal choice. American Economic Review 65(3), 314-325.

[8] Bonomi, E., 2011. Información y menores en conflicto con la ley. Editorial, Ministerio del Interior.

[9] Bretteville-Jensen, A., 1999. Addiction and discounting. Journal of Health Economics 18(4), 393-407.

[10] Burdett, K., Lagos, R., and Wright, R., 2003. Crime, inequality, and unemployment. American Economic Review 93(5), 1764-1777.

[11] Burdett, K., Lagos, R., and Wright, R., 2004. An on-the-job search model of crime, inequality, and unemployment. International Economic Review 45(3), 681-706.

[12] Camp, S., and Gaes, G., 2009. Unintended consequences: Experimental evidence for the criminogenic effect of prison security level placement on post-release recidivism. Journal of Experimental Criminology 5(12), 139-162.

[13] Chen, K., and Shapiro, J., 2007. Do harsher prison conditions reduce recidivism? A discontinuity-based approach. American Law and Economics Review 9(1), 1-29.

[14] Coffey, S., Gudleski, G., Saladin, M., and Brady, K., 2003. Impulsivity and rapid discounting of delayed hypothetical rewards in cocaine-dependent individuals. Experimental and Clinical Psychopharmacology 11(1), 18-25.

[15] DeLisi, M. , Hochstetler, A., Jones- Johnson, G., Caudill, J., and Marquart, J., 2011. The road to murder: The enduring criminogenic effects of juvenile confinement among a sample of adult career criminals. Youth Violence and Juvenile Justice 9(3), 207-221.

[16] Di Tella, R., and Schargrodsky, E., 2009. Criminal recidivism after prison and electronic monitoring. NBER Working Paper 15602.

[17] Ehrlich, I., 1973. Participation in illegitimate activities: A theoretical and empirical investigation. Journal of Political Economy 81(3), 521-65.

[18] Ehrlich, I., 1996. Crime, punishment, and the market for offenses. Journal of Economic Perspectives 10(1), 43-67.

[19] Entorf, H., 2011. Turning 18: What a difference application of adult criminal law makes. IZA Discussion Papers Series Number 5434.

[20] Fagan, J., 1996. The comparative advantage of juvenile versus criminal court sanctions on recidivism among adolescent felony offenders. Law and Policy 18, 77-114.

[21] Flinn, C., 1986. Dynamic models of criminal careers. In Blumstein et al. (Eds.), Criminal Careers and Career Criminals. Panel on Research on Criminal Careers, Committee on Research on Law Enforcement and the Administration of Justice, Commission on Behavioral and Social Sciences and Education. National Research Council.

[22] Green, L., Fry, A., and Myerson, J., 1994. Discounting of delayed rewards: A lifespan comparison. Psychological Science 5(1), 33-36.

[23] Green, L., Myerson, J., and Ostazewski, P., 1999. Discounting of delayed rewards across the life span: Age differences in individual discounting functions. Behavioural Processes 46(1), 89-96.

[24] Green, L., Myerson, J., Lichtman, D., Rosen, S., and Fry, A., 1996. Temporal discounting in choice between delayed rewards: The role of age and income. Psychology and Aging 11(1), 79-84.

[25] Grogger, J., 1991. Certainty vs. severity of punishment. Economic Inquiry 29(2), 297-309.

[26] Hjalmarsson, R., 2009. Juvenile jails: A path to the straight and narrow or to hardened criminality? Journal of Law and Economics 52(4), 779-809.

[27] Holzer, H., 2007. Collateral costs: The effects of incarceration on the employment and earnings of young workers. IZA Discussion Paper 3118.

[28] Huang, C., Laing, D., and Wang, P., 2004. Crime and poverty: A search-theoretic approach. International Economic Review 45(3), 909-938.

[29] Imai, S., and Krishna, K., 2004. Employment, deterrance, and crime in a dynamic model. International Economic Review 45(3), 845-872.

[30] Imrohoroglu, A., Merlo, A., and Rupert, P., 2004. What accounts for the decline in crime?. International Economic Review 45(3), 707-729.

[31] Jensen, E., and Metsger, L., 1994. A test of the deterrent effect of legislative waiver on violent juvenile crime. Crime and Delinquency 40, 96-104.

[32] Junta Nacional de Drogas, 2007. Situación y tendencias del consumo de drogas en Uruguay. Observatorio Uruguayo de Drogas.

[33] Junta Nacional de Drogas, 2010a. Resumen Estadístico del Control de la Oferta. Observatorio Uruguayo de Drogas.

[34] Junta Nacional de Drogas, 2010b. Estudio sobre consumo de drogas y factores asociados en población juvenil con problemas judiciales. Observatorio Uruguayo de Drogas.

[35] Kirby, K., and Petry, N., 2004. Heroin and cocaine abusers have higher discount rates for delayed rewards than alcoholics or non-drug-using controls. Addiction 99(4), 461-71.

[36] Levitt, S., 1996. The effect of prison population size on crime rates: evidence from overcrowding litigation. Quarterly Journal of Economics 111(2), 319-351.

[37] Levitt, S., 1998. Juvenile crime and punishment. Journal of Political Economy 106(6), 1156-1185.

Levitt, S., and Lochner, L., 2000. The determinants of juvenile crime. In J. Gruber (Ed.), Risky Behavior by Youths. University of Chicago Press.

[38] Lochner, L., 2004. Education, work, and crime: A human capital approach. International Economic Review 45(3), 811-843.

[39] Machin, S., Marie, O., and Vujic, S., 2012. Youth crime and education expansion. IZA Discussion Paper 6582.

[40] McCrary, J., 2010. Dynamic perspectives on crime. Handbook of the Economics of Crime, Chapter 4.

[41] Meghir, C., Palme, M., and Schnabel, M., 2012. The effect of education policy on crime: An intergenerational perspective. NBER Working Paper 18145.

[42] Mocan, H., Billups, S., and Overland, J., 2005. A dynamic model of differential human capital and criminal activity, Economica 72(288), 655-681.

[43] Mocan, H., and Rees, D., 2005. Economic conditions, deterrence and juvenile crime: evidence from micro data. American Law and Economics Review 7(2), 319-349.

[44] Myers, D., 2003. The recidivism of violent youths in juvenile and adult court: A consideration of selection bias. Youth Violence and Juvenile Justice 1, 79-101.

[45] Nuñez, J., Rivera, J., Villavicencio, X., and Molina, O., 2003. Determinantes socioeconómicos y demográficos del crimen en Chile. Estudios de Economía 30(1), 55-85.

[46] Nurmi J., 1991. How do adolescents see their future? A review of the development of future orientation and planning. Developmental Review 11(1), 1-59.

[47] Oka, T., 2009. Juvenile crime and punishment: Evidence from Japan. Applied Economics 41(24), 3103-3115.

[48] Pager, D., Western, B., and Bonikowski, B., 2009. Discrimination in a low-wage labor market: a field experiment. American Sociological Review 74(5), 777-799.

[49] Petry, N., 2003. Discounting of money, health, and freedom in substance abusers and controls. Drug and Alcohol Dependence 71(2), 133-41.

[50] Pinchler S., and Romer, D., 2011. Juvenile law and recidivism in Germany: New evidence from the old continent. University of Heidelberg Department of Economics Discussion Paper Series Number 519.

[51] Poder Judicial, 1999 - 2010. Anuario Estadístico. República Oriental del Uruguay.

Podkopacz, M., and Feld, B., 1995. End of the line: An empirical study of judicial waiver. Journal of Criminal Law and Criminology 86, 449-492.

[52] Sanroman, G., 2006. Returns to schooling in Uruguay. Revista de Economía, Banco Central del Uruguay 13(2), 171-194.

[53] Sayagués-Laso, D., 2004. Primeras reflexiones ante la entrada en vigencia del Código de la Niñez y Adolescencia. Espacio Abierto, AFJU.

[54] Sayagués-Laso, D., 2010. Estudio Comparativo. Manuscript.

[55] Sickles, R., and Williams, J., 2008. Turning from crime: A dynamic perspective. Journal of Econometrics 145(1-2), 158-173.

[56] Singer, S., and McDowall, D., 1988. Criminalizing delinquency: The deterrent effects of the New York juvenile offender law. Law and Society Review 22, 521-535.

[57] Steinberg, L., 2009. Adolescent development and juvenile justice. Annual Review of Clinical Psychology 5, 459-485.

[58] Steinberg, L., Graham, S., O'Brien, L.,Woolard, J., Cauffman, E., and Banich, M., 2009. Age differences in future orientation and delay discounting. Child Development 80(1), 28-44.

[59] Steiner, B., Hemmens, C., and Bell, V., 2006. Legislative waiver reconsidered: General deterrent effects of statutory exclusion laws enacted post-1979. Justice Quarterly 23, 34-59.

[60] United Nations, 2003. Juvenile Delinquency. World Youth Report.

[61] Universidad de la República, 2011. Enormes Minucias: La Cuestión de Imputar Penalmente a los Adolescentes. Gaceta UR 13.

[62] Western, B., 2002. The impact of incarceration on wage mobility and inequality. American Sociological Review 67(4), 526-546.

[63] Witte, A., 1980. Estimating the economic model of crime with individual data. Quarterly Journal of Economics 94(1), 57-84.