The Juvenile Crime Dilemma

Ignacio Munyo*
CERES
September 17, 2012

Abstract

I develop a new dynamic framework to analyze crime. In this model, the consistent decisions (between crime and legal activities) of forward-looking youths depend upon their work and crime related skills, which in turn are shaped by their history of past choices. Significant changes in the incentives to engage in criminal activities coupled with an unusual increase in juvenile delinquency make Uruguay an ideal environment to calibrate and test this framework. Model predictions indicate that four factors can account for 86 percent of the observed variation in juvenile crime: the evolution of wages relative to the monetary gains from crime; a new lenient juvenile crime regulation that includes the decriminalization of attempted-theft; an increase in the escape rate from correctional facilities, and a cocaine base epidemic. Counterfactual results suggest 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 alternative not only predicts a similar reduction in juvenile offending but also avoids negative consequences in terms of adult criminal behavior.

Keywords: Crime, Dynamic Programming.

JEL Classification System: K42, D58, D99.

*Email: immuyo@ceres-uy.org. I am grateful to Juan Dubra, Martín Gonzalez-Eiras and Devesh Raval for several helpful discussions. I am also grateful to Daniel Sayagues-Laso and Gustavo Zubía for generous conversations that improved my understanding of the juvenile legal system. I thank Martín Alfaro, Lorenzo Caliendo, Germán Cubas, William Hubbard, Pablo Ottonello, Jorge Ponce, Alejandro Rasteletti, Martín Rossi, Sebastián Strauss, Ernesto Talvi, Federico Weinschelbaum and seminar participants at Universidad de San Andrés, Inter-American Development Bank, Central Bank of Uruguay, Universidad de Montevideo, Universidad Torcuato Di Tella, Universidad Católica de Chile, Universidad de Chile, Universidad de Santiago de Chile, and Universidad Adolfo Ibáñez for very useful comments. The views expressed here are those of the author and not necessarily reflect those of CERES (Center for the Study of Economics and Social Affairs, Uruguay).
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). The delicate intersection between childhood and criminality creates a complex dilemma to deal with. Social scientists, activists, and legislators are all debating both the causes and potential solutions.\(^1\)

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 strongly correlated with later criminal involvement. Social factors, such as income inequality and marginalization, also exert significant influence on youth delinquent behavior. Since Becker (1968), juvenile delinquency can also be thought of as a rational response to the incentives for legal and criminal activities. Some youths will engage in criminal behavior if the potential gains are large enough while the expected punishment relatively low.

Juvenile crime is usually treated quite differently from adult crime. Offenses committed by minors are considered as delinquent acts within a separate juvenile justice system. This system is 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 juveniles as adults in court.

Beyond psychological concerns, invoking the heavy hand of the adult criminal justice system might also raise important 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 after 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 and past choices. In this model, youths are forward-looking and so recognize their present choices affect their future skills and income. This approach incorporates individual heterogeneity since agents with different records face external incentives to crime in a different way 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 majority.

---

\(^1\) 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).
(the age at which individuals become subject to adult courts). The probability of effective apprehension, punishment upon conviction, and evolution of work and crime related skills 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. Previous dynamic models of crime develop significantly different frameworks from the model presented in this paper. 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 juvenile 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 rewards in the job market. Additionally, the introduction of a more lenient juvenile crime regulation and control substantially lowered the expected cost of crime. As a result, 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 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. The model predicts that the anemic evolution of wages relative to the monetary gains from crime (proxied by total per capita income) 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 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 base epidemic, explains 86 percent of 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 for 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 an early transition to adult courts 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 not only would reduce juvenile crime involvement by a similar magnitude but also would minimize the likelihood

---

3 See Becker (1968), Ehrlich (1973), Block and Heineke (1975) and Witte (1980).
4 See Flinn (1986), Imrohoroglu et al. (2004), Burdett et al. (2003), Burdett et al. (2004), Huang et al. (2004), Lochner (2004), Sickles and Williams (2008); and McCrary (2010) for a review of this literature.
of criminal involvement later in life, once juveniles become adults.

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 worse than the disease, as the model predicts a harsher punishment could even increase juvenile 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 analyzes 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 life, 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, $\beta$ 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 skills, work-related skills $H$ and crime-related skills $B$, which evolve based upon their choices.

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 $F(w(\cdot)) = \Pr(w(\cdot) \leq w_i)$. 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 the next 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 they will be able to choose again between work and crime. However, individuals are able to escape from detention centers with probability $\varepsilon$. Agents who escape from the detention center also receive zero income in the current period and are free to choose between work or crime the next period. The current income of those 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 the next period.

In all the cases, the continuation value next period depends upon 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 $\tau$. The probability of apprehension, the probability of escape and the punishment once caught 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:

$$V(w_t, H_t, B_t, t) = \max_{\text{Work}, \text{Crime}} \left\{ \begin{array}{l}
w_t H_t + \beta E_t V(w_{t+1}, H_{t+1}, B_{t+1}, t+1), \\
\left[ P_t (1 - \varepsilon_t) [\beta^s E_t V(w_{t+s}, H_{t+s}, B_{t+s}, t + s)] \right] \\
\quad + P_t \varepsilon_t \beta E_t (w_{t+1}, H_{t+1}, B_{t+1}, t + 1) \\
\quad + (1 - P_t) [g B_t + \beta E_t V(w_{t+1}, H_{t+1}, B_{t+1}, t + 1)] \end{array} \right\}$$

(1)

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

There are a finite number of both skill levels whose dynamics depend on 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 their complete sentence imposed by the judge have 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>
<thead>
<tr>
<th></th>
<th>$H_{t+1} =$</th>
<th>$B_{t+1} =$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Work</td>
<td>$H_t + \alpha_i$ with $\alpha_i &gt; 0$</td>
<td>$B_t$</td>
</tr>
<tr>
<td>Crime + Sentence</td>
<td>$H_t - \eta_i$ with $\eta_i &gt; 0$</td>
<td>$B_t + \gamma_i$ with $\gamma_i &gt; 0$</td>
</tr>
<tr>
<td>Crime + Escape</td>
<td>$H_t - \eta_i$ with $\eta_i &gt; 0$</td>
<td>$B_t + \chi_i$ with $\chi_i &gt; 0$</td>
</tr>
<tr>
<td>Crime + Free</td>
<td>$H_t$</td>
<td>$B_t + \chi_i$ with $\chi_i &gt; 0$</td>
</tr>
</tbody>
</table>

This endogenous evolution of skills recognizes both the stigmatization and the school-of-crime effects of incarceration. The stigmatization effect refers to the fact ex-offenders’ earnings are low, even after controlling for their weak labor market characteristics (Western 2002; Holzer 2007). 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 strictly segregated from adults in custody.

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

\[
V(w_t, H_t, B_t, t) = \max_{\text{work, crime}} \left\{ \begin{array}{l}
\frac{w_t H_t + \beta \int_{w_{t+1}} V(w_{t+1}, H_t + \alpha_i, B_t, t + 1) dF(w_{t+1})}{P_i (1 - \varepsilon_i)} \left[ \beta s_i \int_{w_{t+1}} V(w_{t+1}, H_t - s_i \eta_i, B_t - s_i + s_i \gamma_i, t + s_i) dF(w_{t+1}) \right] \\
+ P_i \varepsilon_i \left[ \beta \int_{w_{t+1}} V(w_{t+1}, H_t - \eta_i, B_t + \chi_i, t + 1) dF(w_{t+1}) \right] \\
+ (1 - P_i) \left[ g B_t + \beta \int_{w_{t+1}} V(w_{t+1}, H_t, B_t + \chi_i, t + 1) dF(w_{t+1}) \right]
\end{array} \right\}
\]

(2)

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

**Equilibrium Dynamics**

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:

\[
J(w_t, H, B, t) = [1 - C(w_{t-1}, H - \alpha_j, B, t - 1)] J(w_{t-1}, H - \alpha_j, B, t - 1) \\
+ \left[ P_j (1 - \varepsilon_j) C(w_{t-1} - s_j \eta_j, H + s_j \eta_j, B - s_j \gamma_j, t - s_j) \\
J(w_{t-1} - s_j \eta_j, H + s_j \eta_j, B - s_j \gamma_j, t - s_j) \\
+ P_j \varepsilon_j C(w_{t-1}, H + \eta_j, B - \chi_j, t - 1) J(w_{t-1}, H + \eta_j, B - \chi_j, t - 1) \\
+ (1 - P_j) C(w_{t-1}, H - \chi_j, t - 1) J(w_{t-1}, H - \chi_j, t - 1) \right] \]

(3)

The first addend on the right hand side of the equation (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 \(w_{t-1} - s_j \eta_j\), 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:

$$JC = \int \sum_{w} \sum_{H} \sum_{B} \sum_{t=0}^{T-1} J(w_t, H, B, t) C(w_t, H, B, t) dF(w_t)$$

Equation (4) tracks only changes in the number of active offenders, not the total number of crimes committed. However, given that the literature has typically found a constant offending rate of active offenders at any given age (Loeber and Snyder 1990), the relative change in $JC$ in a given period should account for the total variation in juvenile offending in such a period.\footnote{A shortcoming of the analysis is the potential instability of the offending rate of active offenders (the so-called lambda in the literature). This is relevant for section V since it could be argued that a constant lambda through time is no longer true when analyzing significant changes in policy.}

### 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 $\beta$ 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>
<thead>
<tr>
<th>Parameter</th>
<th>Juveniles ($i = j$)</th>
<th>Adults ($i = a$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$P_i$ Probability of Apprehension</td>
<td>10%</td>
<td>10%</td>
</tr>
<tr>
<td>$s_i$ Average Sentence Length</td>
<td>$2Q$</td>
<td>$5Q$</td>
</tr>
<tr>
<td>$\varepsilon_i$ Probability of Escape</td>
<td>11%</td>
<td>0</td>
</tr>
</tbody>
</table>

I estimate the probability of apprehension as the ratio of total prosecutions to total offenses after adjusting data on police-recorded offenses for an underreporting rate of 60 percent.\footnote{The underreporting rate, which is in line with the rate estimated for the U.S. (Levitt 1996) and for Chile (Nuñez at al. 2003), was computed considering government estimates (Universidad de la República 2011) and own calculations based on victimization surveys (Latin American Public Opinion Project -Vanderbilt University 2010).} This probability is 10 percent for both juveniles and adults. I then estimate an 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.\textsuperscript{7} Information on effective sentence lengths is not available for juveniles. However, Uruguayan juvenile crime specialists state that the effective average sentence length for juveniles was about 2 quarters in 1997. I define the probability of escape as the ratio between number of prison breaks and total number of inmates, which differs before and after the age of majority. This probability was 0.4 percent for adults (Poder Legislativo 2007) and 11 percent for youths (Instituto del Niño y Adolescente del Uruguay 2011).

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).\textsuperscript{8} By design, PISA test scores reflect the aptitude for the job market for a representative sample of Uruguayan youths. Due to lack of information, I assume a uniform distribution of crime-related skills.\textsuperscript{9}

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 \([1, 2]\). 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 for adults and juveniles if the police catch 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 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. Finally, if agents are apprehended after crime and serve the complete sentence, the reduction in work-related skills and the increase in crime-related skills are five times higher in the case of adults as the stigmatization effect is higher and the school-of-crime effect is stronger with more experienced teachers.

\footnote{\textsuperscript{7}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.}

\footnote{\textsuperscript{8}The first participation of Uruguay in PISA was in 2003.}

\footnote{\textsuperscript{9}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).}
Table 3. Skill Parameters.

<table>
<thead>
<tr>
<th>Work-Related Skills (H)</th>
<th>Crime-Related Skills (B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parameter</td>
<td>Juveniles</td>
</tr>
<tr>
<td>Work</td>
<td>$\alpha_i$</td>
</tr>
<tr>
<td>Crime + Sentence</td>
<td>$\eta_i$</td>
</tr>
<tr>
<td>Crime + Escape</td>
<td>$\eta_i$</td>
</tr>
</tbody>
</table>

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 $\bar{w}$.

Finally, I calibrate the only free parameter of the model, the time invariant mean wage per unit of work-related skill relative to the monetary gain per unit of crime-related skill $\bar{w}/g$, to reproduce the observed juvenile crime rate in Uruguay in 1997.\(^{10}\)

**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 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).\(^{11}\)

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 laxer juvenile crime regulation, the increase

---

10 I assume that only a minority of those youths with high incentives for crime actually engage in crime. Empirical evidence suggests 13 percent of individuals engage in profitable illegal activities even when their actions could not be witnessed (Levitt and Dubner 2005).

11 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 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 (Savagués-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.
in the breakout rate from correctional facilities, and the cocaine base epidemic are all relevant factors to analyze. For each factor, I compute the model predicted increase of juvenile crime (consistent with the changes observed in Uruguay). Finally, I compare the model prediction and the actual change observed between 1997 and 2010. Table 4 presents the results.

Table 4. Factors Affecting Juvenile Crime’s Dynamics.12

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Baseline</th>
<th>(1)</th>
<th>(2)</th>
<th>(3) + (4)</th>
<th>(5) + (6)</th>
<th>(5) + Drugs</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\pi/g$</td>
<td>1.4</td>
<td>1.4</td>
<td>1.4</td>
<td>1.4</td>
<td>1.4</td>
<td>1.4/1.2</td>
</tr>
<tr>
<td>$P_j$</td>
<td>10%</td>
<td>10%</td>
<td>6%</td>
<td>6%</td>
<td>10%</td>
<td>6%</td>
</tr>
<tr>
<td>$s_j$</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>$\varepsilon_j$</td>
<td>11%</td>
<td>11%</td>
<td>11%</td>
<td>11%</td>
<td>38%</td>
<td>38%</td>
</tr>
<tr>
<td>$\beta$</td>
<td>0.986</td>
<td>0.986</td>
<td>0.986</td>
<td>0.986</td>
<td>0.986</td>
<td>0.981</td>
</tr>
</tbody>
</table>

Increase in Juv. Crime 63% 69% 118% 21% 136% 155%

% of Actual Increase 35% 38% 65% 13% 75% 86%

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 then began to recover. However, while in 2010 real per capita income was 34 percent above its 1997 level, real private wages were only 12 percent above pre-crisis peak. This observed gap between wages and per capita income affects the individual return to crime if monetary gains from crime per unit of crime-related skills increase hand in hand with per capita income. To assume 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.13 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 $\pi/g$ 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 $\pi/g$.14 The model predicts an increase of 113 percent in adult crime whereas the number

---

12Matlab codes available upon request.
13According 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 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.
14The variation in adult crime is given by the change in $\int_{\mathcal{H}} \sum_{\mathcal{B}} \sum_{t=0}^{T} f(w_t; H, B, t) C(w_t, H, B, t) F(w_t)$. 

10
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.

Figure 1 illustrates juveniles’ incentives to either commit crime or to work as a function of both skill levels: the higher (lower) the work-related skills and the lower (higher) the crime-related skills, the larger (smaller) the region where incentives to work are stronger than those to commit crime. Given the observed evolution of per capita income and wages, the shaded critical area, denoting the combination of skills that make it profitable to engage in criminal activities, expands from 0.02 percent to 7.8 percent of the total area. Additionally, the number of youths with the combination of skills that make crime profitable increases over time, as criminal activity increases crime-related skills and decreases work-related skills.

Figure 1. Skills and Incentive Regions.

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 for offenses committed by minors.\footnote{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.} According to specialists, 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 (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). Again, the region of skills for which incentives to engage in crime are higher than those to work expands significantly to reach 24 percent of the total area (see Figure 1).

The third factor I consider to explain the evolution of juvenile delinquency in Uruguay is the rise in the escape rate from correctional facilities. In fact, the probability of escape from detention centers $\epsilon_j$ jumps from 11 percent in 1997 to 38 percent in 2010 (Instituto del Niño y Adolescente del Uruguay 2011). 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 (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). A new expansion that reaches 40 percent of the total area of the critical region of skills where the incentives to commit crime are stronger than those to work lies behind such a significant increase in juvenile delinquency (see Figure 1).

Finally, I introduce a fourth factor into the analysis: the cocaine base epidemic. The incidence of cocaine base among adolescents has skyrocketed in Uruguay since 2003. Official statistics indicate that cocaine base 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 cocaine base (Junta Nacional de Drogas 2007) and cocaine base incidence among inmates in juvenile correctional facilities is 53 percent (Junta Nacional de Drogas 2010b). Becker and Mulligan (1997) develop a theoretical model in which drug addiction causes a rational increase in future discounting. Moreover, experimental studies show that drug consumption increases discount rates by a factor close to five (Bretteville-Jensen 1999; Petry 2003; Coffey et al. 2003; Kirby and Petry 2004). To recognize this change in the capacity to project events into the future in the target population, I exogenously reduce the value of parameter $\beta$ from 0.986 to 0.981.

All four 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 cocaine base epidemic are able to explain 86 percent of the observed variation in youth delinquency (see column (6) of Table 4). The critical region of skills in which the incentives to commit crime are stronger than those to work expands

---

16 According to members of the Supreme Court of Justice, juveniles are currently punished with sentences that are only 1/6 of those applicable to adults for the same type of offense.
to 44 percent to the total area (see Figure 1). This, combined with a new increase in the number of free youths endowed with such skills combinations produce the predicted increase in juvenile offending.

Moreover, if I consider the observed dynamics of each of these key factors affecting youth’s decisions year by year, the model almost replicates the actual time series of juvenile crime in Uruguay (see Figure 2).\footnote{To compute the time series of the key factors affecting juvenile crime, I proceed as follows. Real wages and per capita income evolve according to official statistics. I think in two periods in order to compute the time series of the probability of apprehension and the average sentence length facing youths. Between 1997 and 2003, I consider constant values at pre-new-juvenile-crime-regulation levels. Between 2004 and 2010, I consider constant values consistent with the new juvenile crime code. I compute the time series of the probability of escape between 2005 and 2010 with available official data. Due to lack of information, I have to impute to the period 1997-2004 the observed value in 2005. Finally, I extrapolate the evolution of the discount factor considering the observed variation in cocaine base seizures.}

Figure 2. Evolution of Juvenile Crime.

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 actual 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 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 vain, it should come as no surprise either that records on judicial interviews with adolescents reveal more than 50 percent of youths involved in criminal activities in Uruguay state 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 in order to analyze the effectiveness of alternative policies in the fight against juvenile crime.

I first adjust the initial parameterization to reproduce 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 ($\bar{w}/g = 1.4/1.2$). For juveniles, the new probability of effective apprehension ($P_j = 6\%$), the new average sentence length ($\pi_j = 1$) and the new probability of escape ($\varepsilon_j = 38\%$) have to reflect a more lenient expected punishment for potential offenders. The current discount factor ($\beta = 0.981$) has to be consistent with the cocaine base 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 consensual way to fight 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 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, see Figure 3) 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.

Figure 3. Work-Related-Skills Distribution.
Under this scenario, legal activities would become more attractive than crime for a large set of Uruguayan youths. However, it would require a deep reform in the Uruguayan education system to significantly reduce the number of juveniles without the minimum requirements for productive insertion in the labor market. 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 to partially eliminate the separate juvenile justice system, treating some adolescents by adult standards of criminal culpability and punishment. Early transition to adult courts implies key 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 nil probability to escape from detention centers instead of 38 percent, the model predicts a reduction a 35 percent reduction in youth delinquency.\(^{18}\) The deterrence argument that harsh punishments reduce criminal involvement holds once the age of majority is reduced.\(^{19}\)

Table 5. Increase in the Expected Punishment of Juveniles.

<table>
<thead>
<tr>
<th>Model</th>
<th>Early Transition to Adult Courts</th>
<th>Harsher Juv. System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parameter</td>
<td>Baseline Policy</td>
<td>Baseline Policy</td>
</tr>
<tr>
<td>(P_j)</td>
<td>6% 6%</td>
<td>6% 6%</td>
</tr>
<tr>
<td>(s_j)</td>
<td>1Q 1Q</td>
<td>1Q 1Q</td>
</tr>
<tr>
<td>(\varepsilon_j)</td>
<td>38% 38%</td>
<td>38% 38%</td>
</tr>
<tr>
<td>(\eta_j)</td>
<td>0.0075 0.0075</td>
<td>0.0075 0.0075</td>
</tr>
<tr>
<td>(\gamma_j)</td>
<td>0.0075 0.0075</td>
<td>0.0075 0.0075</td>
</tr>
</tbody>
</table>

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

I alternatively evaluate measures that would imply harsher expected punishment for juveniles but maintain the trying of minors in juvenile courts (see Table 5). For starters, it implies the complete elimination of escapes from youth detention centers thanks to tighter security measures. This measure should be complemented with 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.

\(^{18}\)Matlab codes available upon request.

\(^{19}\)In fact, some lab experiments suggests that only strong punishments deter crime (Schildberg-Hörisch and Strassmair 2010).
Both the reduction of the age of majority and the increase in the expected punishment in the juvenile system predict a similar reduction in youth crime. However, model results suggest opposite effects on criminal involvement once current juveniles become adults.\textsuperscript{20} While the increase in the expected level of punishment in the juvenile system reduces future adult crime by 10 percent, an early transition to adult courts increases the incentives for crime later in life as adult crime increases 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. 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).

Rehabilitation of youth offenders should thus be the first order of business. Rehabilitation could be consistent with a longer sentence if it enhances work-related skills. However, if the increase in crime-related skill in correctional facilities were strong enough, the model suggests that longer sentences, under either the adult or juvenile system, could even increase juvenile crime rates.

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

A possible extension of this model would be the introduction of government behavior. The government would decide the total expenditure in the fight against crime and how to allocate these resources. A standard approximation would be to minimize the present discounted value of the crime burden by choosing both the investment in street surveillance and the resources spent to manage detention centers, subject to an intertemporal budget constraint. However, I decided to exclude government behavior from the analysis for two reasons. First, this is a model analyzing the behavior of minors, who represent only 8 percent of the total population. Thus, in order to introduce the government, I would also have to introduce taxes paid by adults to finance government expenditure, and the behaviour of adults is out of the scope of this model. Second and more importantly, given that the magnitude of the elasticity of police crime surveillance remains undefined in the literature (Levitt 2002), government behavior would be impossible to calibrate with precision. The exclusion of the public sector prevents the introduction of government welfare transfer payments into the

\textsuperscript{20}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 \( \int_{w} \sum_{H} \sum_{B} \sum_{t=\tau}^{\tau + 10} J(w_{t}, H, B, t) C(w_{t}, H, B, t) dF(w_{t}) \).
model, which could affect the decision between working or committing crime. In fact, while unconditional transfer payments would have no effect on the model’s decisions, conditional ones (on legal activities) could affect the individual’s choice to engage in either legal or criminal activities.

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 alternative 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 legal 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 in the upward side.

The introduction of harsher punishments should seek to avoid the school-of-crime effects of juvenile confinement. Empirical evidence suggests that the social environment of juvenile correctional centers is criminogenic due to peer influence (Bayer at al. 2009; DeLisi et al. 2011). 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 (2010), 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


