AN INTERTEMPORAL MODEL OF RATIONAL CRIMINAL CHOICE

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ABSTRACT

This research presents a dynamic model of crime in which agents anticipate future consequences of their actions. Current period decisions affect future outcomes by a process of capital accumulation. While investigating the role of human capital, the focus of our study is on a form of capital that has received somewhat less attention in the literature, social capital. Social capital is an index of one's 'stock' in society. Introduction of social capital into the utility function results in an intertemporally nonseparable preference structure which admits state dependence in the decision to participate in crime. Our model is empirically implemented using panel data on a sample from the 1958 Philadelphia Birth Cohort Study. In estimation, we take account of unobserved choices in states not realized, which potentially depend on individual specific heterogeneity, by using simulation techniques. Our results provide evidence of state dependence in the decision to participate in crime. We also find that the initial level of social capital stock is important in determining the pattern of criminal involvement in adulthood.

Keywords: Social Capital, Dynamic Model, Panel Data, Simulated Method of Moments
1. INTRODUCTION

Rational criminal choice has traditionally been studied in an atemporal time allocation model, where rationality is myopic\(^1\). However, the empirical relationship referred to as the age-crime profile (Quetelet (1834,[1831]), Hirschi and Gottfredson (1983), Wolfgang, Thornberry and Figlio (1987), Leung (1994)) has found aggregate arrests to be a unimodal positively skewed function of age across different time periods and countries. This evidence suggests that life-cycle issues are important in explaining criminal choice, and therefore, myopic rationality is too restrictive. In this research we present a dynamic model of crime in which agents anticipate future consequences of their actions. Further, we adopt an intertemporally nonseparable preference structure which is consistent with the existence of state dependence in the decision to participate in crime.

In developing an intertemporal model of crime, we draw on literature from labor supply (Heckman, 1981; Kydland and Prescott, 1982; Johnson and Pencavel, 1984; Nakamura and Nakamura, 1985; Hotz, Kydland and Sediacek, 1988), health (Grossman, 1972; Muurinen; 1982; Wolpin, 1984; Rosenzweig and Wolpin, 1988; Sickles and Yazbeck, 1997) and rational addictions (Becker and Murphy, 1988; Becker, Grossman and Murphy, 1994), which finds evidence of state dependence operating through individual's preference structure and earnings.\(^2\) In these models, introducing a capital stock into the utility function causes preferences to be temporally nonseparable. This results in a form of state dependence where optimal current period decisions take into account their expected affect on future utility through the capital accumulation process\(^3\). Current decisions also impact future welfare through the effect of the capital stock on life-cycle wages. In the models of labor supply cited above, this capital stock is typically human capital, in models of health it is health capital, while in models of rational addiction the relevant stock is consumption capital. Our intertemporal model of crime assumes that an individual's preferences

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1 This model has generated an extensive and influential literature on deterrence. For good reviews of this literature, see Heineke, 1978; Schmidt and Witte, 1984; Eide, 1994.
2 For a survey of these generic models in the context of dynamic structural models of health, see Sickles and Taubman (1997) and Behrman et al. (1997).
3 Our formulation is also consistent with the interpretation that 'standards by which individuals gauge their well being are molded by their prior experiences' (Johnson and Pencavel, 1984).
and earnings are influenced by his stock of social capital, where social capital is defined as an index of one's 'stock' in society.

Human, health, and addictive consumption capital, as well as social capital are each likely to play a role in determining participation in crime. Health capital plays a significant role in older individual's decisions, while addictive consumption capital influences those with an addiction. Our sample consists of males in their youth and does not contain information on addiction. Previous studies of crime have paid particular attention to the role of human capital. This literature views criminal activity as similar to employment in that it requires time and produces income (Ehrlich, 1973)⁴. Individual's who face a lower wage, having accumulated a smaller stock of human capital, incur a lower opportunity cost of engaging in crime in terms of forgone earnings and are therefore more likely to participate in crime. Empirical evidence regarding this hypothesis is mixed. A growing number of studies using individual level data have failed to find a significant negative relationship between criminality and labor market earnings or wages⁵. They do find, however, evidence that interaction between individuals and their community, working through peer influences, attitudes to crime, information (about criminal or legitimate opportunities), influence the decision to participate in crime. We draw on this evidence as a basis for our focus on social capital in our theoretical model, while considering both human and social capital effects in our empirical specification.

Defining crime as behavior deemed deviant by society, and social capital as a measure of one's 'stock' in society⁶, social capital is then the mechanism that links an individual

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⁴ Crime is distinguished from employment since net income from crime has a state contingent component. If an individual is successful in escaping apprehension, he reaps the entire value (pecuniary and monetary equivalent of nonpecuniary income) of his illegitimate activity. If apprehended, his income will be reduced by a fine, which is the monetary equivalent of the punishment meted out.


⁶ The concept of social capital was introduced into the sociology literature by Coleman (1988). It measures the bondedness of an individual to society. Social capital consists of three components: networks for disseminating and obtaining information (e.g. about job opportunities), a reward and punishment system, and a system of reciprocal debts and obligations (Coleman, 1988). Laub and Sampson (1993) link social capital with informal social. According to social control theory, it is the bonds an individual has to conventional social groups that generate the potential cost of social sanctions, and this in turn restrains misbehavior. Informal social control theory emphasizes the
to society. The importance of the interaction between individuals and their community in forming tastes and determining criminal choices has been studied by Glaeser, Sacerdote and Scheinkman, 1996; Akerlof and Yellen, 1994; and Sah, 1991. A common theme in these papers is that the stigma or community norms associated with crime influences individual behavior. Our study goes further by recognizing that the ability of society to stigmatize an individual depends upon that individual’s stock in society. Where human capital can be attributed wholly to an individual, social capital includes the links between the individual and society.

We assume that an agent’s stock in society is reflected by his social capital stock. An individual inherits an initial stock from his family that depreciates over time, and can be increased by investment. Gross investment is generated as a byproduct of engaging in legitimate activities that develop institutional relationships, such as stable attachments to the workforce and marriage. In addition to depreciation, an individual’s social capital stock is reduced in the event of being caught engaging in crime. This reduction is affected through a social sanction, which may entail marriage breakdown or loss of one’s job or reputation. As an investment good, social capital enters directly into the individual’s preference function representing the utility value of reputation, and the earnings function representing the monetary value of networks and institutional knowledge components of social capital.

The intuition behind our model is that attachment to society through, for example, productive employment and marriage, creates a form of state dependence which reduces the likelihood of criminal involvement. In our formulation, this effect is reinforced since state dependence imposes higher potential costs of engaging in crime: individuals who have good jobs or families have more to lose if caught committing crimes than those without such attachments. Our approach is also consistent with a model of criminal activity that conceives of legitimate time uses and social associations (e.g., participation in church activities, white collar employment) as

\[\text{influence of institutional relationships such as family, work, and community on the likelihood of deviance. The recent survey by Miller (1997, p. 1178) also discusses the interplay of social networks on the rational voter paradigm utilized in public choice.}\]
shaping preferences concerning illegal activities\(^7\). In this sense, social capital is an index of an individual's propensity for noncriminal behavior.

In our theoretical model of crime, decisions are made under uncertainty since individuals do not know if they will be arrested. The ex-ante optimality conditions then depend on (state contingent) choices in each of two possible future states, apprehension and escaping apprehension. However, only one of these future states will be realized and the corresponding choice observed in the data. The unobserved choices in states not realized are problematic as they cause an omitted regressor problem in estimation, and are a potential source of unobserved heterogeneity. We address these issues using simulation techniques and estimate the parameters of our model by Simulated Method of Moments (McFadden, 1989; Pakes and Pollard, 1989; McFadden and Ruud, 1994).

The remainder of this paper is organized as follows. In the next section, we present a life-cycle model of crime which merges the intertemporal choice literature with Ehrlich's atemporal time allocation model of crime. In section 3 we discuss the method for estimating the structural parameters of the model. Section 4 provides a description of the 1958 Philadelphia Birth Cohort Study (Wolfgang, Figlio and Tracy, 1988), which is used to estimate our model. With a universe of all individuals born in 1958 who lived in Philadelphia at least from their tenth until their eighteenth birthday, this data set presents a unique opportunity to study the dynamic decision to participate in crime. We also provide a discussion of the construction of the index of social capital stock. Section 5 presents our results from estimation. In section 6, we offer some concluding remarks.

2. THE MODEL

In the theoretical model of crime that follows, an individual's welfare is assumed to depend upon his level of social capital stock, representing his 'stock' in society\(^8\). In

\(^7\) Tauchen, Witte, and Greisinger (1988) and Witte and Tauchen (1994) find evidence of these effects in the decision to participate in crime.

\(^8\) A more general specification would allow both human and social capital stocks to influence welfare directly in the structural model. While relaxing this assumption poses no problem for the mathematical model, it does cause complications for the empirical model as we are no longer able to obtain closed
our formulation, social capital is hypothesized to influence individual's behavior in two ways. First, through preferences; in part, social capital represents reputation and social acceptance. This has utility value to the individual. Second, social capital affects labor market earnings. Social capital includes the networks that are built up at work and in the community through labor market experience. For instance, these networks serve to disseminate information about opportunities for advancement in the legitimate sector.\textsuperscript{9} We captured this effect by allowing the accumulation of social capital to raise market earnings.

In breaking the law, an agent risks a reduction in his social capital stock since an arrest entails a social sanction\textsuperscript{10}. The sanction is assumed to be increasing in social capital so that, \textit{ceteris paribus}, crime is more costly (and therefore less likely) for those who have a greater stock in their community. Whether a social sanction is to be imposed is uncertain; it depends on whether the individual is apprehended. We build uncertainty into the model by making use of a common generalization about the nature of crime. Crime is characterized as providing immediate rewards, while punishment is seen as uncertain and in the distant future. This stylized fact is incorporated into our model by temporally separating the commission of crime from the incidence of the expected punishment. Crimes committed in the current period will be punished next period with probability, \( p \).\textsuperscript{11}

At the beginning of each period, the representative agent must decide on his level of consumption, \( X_t \), and the amount of time to allocate to work, \( L_t \), to crime which

\textsuperscript{9} Empirical evidence regarding the use of informal social resources in achieving occupational mobility in the United States and, to a lesser extent, in West Germany and the Netherlands is found in Li (1988) and DeGraaf and Flap (1988).

\textsuperscript{10} Social sanction may include job termination, or marriage breakdown. Unlike the traditional time allocation model of crime, we do not consider the monetary equivalent of the punishment. This omission is a result of data limitations. The Philadelphia Cohort Study contains arrest data, but no information on convictions or punishments.

\textsuperscript{11} The probability of apprehension is treated as exogenous and constant in this model. Relaxing this assumption poses no problem for the mathematical model. However, it introduces complications for estimation since we no longer are able to obtain closed form solutions for the Euler equations.
produces income, $C_t$, and leisure, $\ell_t$, where time represents resources devoted to each activity. The utility of an individual at any point in time depends on consumption of the composite market good, $X_t$, the level of leisure, $\ell_t$, and the stock of social capital, $S_t$. At time $t$, utility is given by:

$$ U(X_t, \ell_t, S_t). $$  

The utility function, $U(.)$, is twice differentiable, concave, and increasing in its arguments. Denoting earnings within a period in terms of the composite good, $X_t$, the intertemporal budget constraint is given by:

$$ A_{s+1} = (1 + r)\left(A_t + W_e(L_t, S_t) + W_c(C_t) - X_t\right) $$  

where $W_e(L_t, S_t)$ is income from legitimate activity, $W_c(C_t)$ is income from illegitimate activity, and $A_t$ represents the value of accumulated assets. We assume that income from legitimate and illegitimate activities are increasing in their respective arguments. Note that pecuniary rewards from income producing crime are certain since, by assumption, they depend only on the amount of resources devoted to this activity. Income from legitimate endeavors depends on both current period resources devoted to its pursuit and the level of social capital accumulated by the individual. Since the state of the world - apprehended for last period's crime, or escaped apprehension for last period's crime - and therefore the individual's level of social capital, is revealed at the beginning of each period, legitimate income in the current period is also certain. However, future earnings in the legitimate sector

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12 In earlier versions of this paper, both pure income and pure utility generating crimes were included in the model, where utility generating crime included rape and murder. However, the data did not contain sufficient information to identify the effect of utility generating crimes. Hence, we have simplified the model by only considering income generating crimes.

13 In our empirical model, labor market earnings also depend on human capital as measured by educational attainment.

14 $\frac{\partial W_e(L_t, S_t)}{\partial L_t} = 0, \frac{\partial W_e(L_t, S_t)}{\partial S_t} = 0, \frac{\partial W_c(C_t)}{\partial C_t} = 0

15 In reality, there may be many sources of uncertainty in the returns to crime, such as varying degrees of self-protection by potential victims.
depend on future levels of social capital, which are uncertain. Uncertainty about
future welfare is also introduced via the direct utility effect of social capital.

Social capital is cumulative and investment will be considered as proportional to the
level of effort and other resources spent in legitimate activity. Resources in this
model are represented by time. Social capital also depends on the state of the world,
which is learnt at the beginning of each period. In the event of not being apprehended
(State 0) for crimes committed in time $t$, which occurs with probability $(1-p)$, social
capital at $t+1$ is given by:

$$S_{t+1}^0 = (1 - \delta)S_t + \gamma L_t$$  \hspace{1cm} (2.3)

where $\delta$ is the depreciation rate of social capital and $\gamma$ transforms resources spent in
legitimate activity into social capital\textsuperscript{16}.

With probability, $p$, the individual will be apprehended (State 1) at the beginning of
$t+1$ and a social sanction imposed. This sanction is represented by a loss to the
individual’s social capital stock. The loss will depend positively on the total amount
of time devoted to crime and the level of social capital stock the individual has
accumulated. Thus, in the event of apprehension, social capital at the beginning of
$t+1$ is given by:

$$S_{t+1}^1 = \{(1 - \delta) - \alpha C_t\}S_t$$  \hspace{1cm} (2.4)

where $\alpha$ represents the technology that transforms resources spent in crime into a
social sanction.

\textsuperscript{16} Labor market experience increases an individual’s stock of institutional knowledge, and networks,
which we consider to contribute to social capital, but could also be interpreted as human capital. For
the purpose of the theoretical model, we consider social capital to encompass human capital. This
interpretation becomes problematic in the event that a social sanction imposed, if human capital is
wholly embodied within the individual, and therefore not subject to such sanctions. We attempt to
distinguish between strictly human capital, such as educational attainment, and that acquired from labor
market experience, which we interpret as social capital in our empirical model.
A representative individual's dynamic programming problem is characterized by his value function at period $t$, $V(A_t, S_t)$, which is the solution to the Bellman equation:

$$V(A_t, S_t) = \max_{x_t, l_t, c_t} U(x_t, l_t, s_t) + \beta \left\{ pV(A_{t+1}, S_{t+1}) + (1 - p)V(A_t, S_{t+1}) \right\}$$

Subject to a time constraint, $T = t + L_t + C_t$, 2.2, 2.3 and 2.4. By substituting the time constraint in for $l_t$, we eliminate it as a choice variable. Taking first order conditions and making use of the Envelope Theorem, we obtain the following set of Euler equations$^{17}$:

$$X_t: U_t(t) - \beta(1 + r)\left\{ pU_t'(t + 1) + (1 - p)U_t^o(t + 1) \right\} = 0$$

$$L_t: U_t(t) \frac{\partial W_L(L_t, S_t)}{\partial L_t} - U_t(t) + \beta \gamma(1 - p)\left\{ \left( \frac{1 - \delta}{\gamma} - \frac{1 - \delta - \alpha C_t}{\alpha S_t^o} \right)U_t^o(t + 1) \right\} + \left( \frac{\partial W_L(L_t^o, S_t^o)}{\partial S_t^o} + \frac{1 - \delta - \alpha C_t^o}{\alpha S_t^o} \frac{\partial W_L(C_t^o)}{\partial C_t} \right) \left\{ U_t^o(t + 1) + U_t^o(t + 1) \right\} = 0$$

$$C_t: U_t(t) \frac{\partial W_L(C_t)}{\partial C_t} - U_t(t) - \beta\alpha p S_t \left\{ \left( \frac{1 - \delta}{\gamma} - \frac{1 - \delta - \alpha C_t}{\alpha S_t^o} \right)U_t^o(t + 1) \right\} + \left( \frac{\partial W_L(L_t^o, S_t^o)}{\partial S_t^o} + \frac{1 - \delta - \alpha C_t^o}{\alpha S_t^o} \frac{\partial W_L(C_t^o)}{\partial C_t} \right) \left\{ U_t^o(t + 1) + U_t^o(t + 1) \right\} = 0$$

Notice that the Euler equation for the aggregate consumption good gives the usual condition for optimality in consumption. The ratio of the marginal utility of current period consumption to the expected marginal utility of next period's consumption is equated to the gross real rate of interest. The Euler equation for time spent in the

$^{17}$ The derivation of the Euler equations is given in Appendix 1.
labor market equates net current period costs associated with time at work to the expected value of the increase in social capital in terms of next period decision variables. Similarly, the Euler equation for time spent in illegitimate income generating activities equates the net marginal benefit this period to the expected future cost. Once functional forms are specified for the utility and earnings functions, the system of three Euler equations and two earnings equations give a closed form solution for the optimal allocation of resources.

3. ECONOMETRIC MODEL
The structural model developed in the previous section characterizes the behavior of a representative individual by a system of five equations. Three of these are Euler equations, which depend on future choices under two states of nature, apprehension, and escaping apprehension. Since only one future state is realized for each individual, choices corresponding to the unobserved state cause an omitted regressor problem in estimation. The earnings equations do not depend on parameters from the utility function, nor do they depend on decisions made in (potentially unobserved) future periods. While it is possible to estimate all five equations simultaneously, the absence of unobserved future states in the earnings equations makes a sequential estimation process computationally convenient. We begin by estimating the parameters in the earnings equations. The Euler equations are then estimated in a second step using Simulated Method of Moments (McFadden and Ruud, 1994; McFadden, 1989; Pakes and Pollard, 1989).

3.1 Estimation Methodology for the Earnings Equations
We adopt the following functional form for an individual's earnings in the legitimate sector\(^\text{18}\):

\[
W_i(L_i, S_i) = \eta_0 + \eta_1 L_i + \eta_2 L_i^2 + \eta_3 L_i S_i + \eta_4 ED + \eta_5 L_i ED_i + \eta_6 SCH + \epsilon_{t_i}.
\]

Illegitimate earnings are parameterized by:

\(^{18}\) These functional forms satisfy the conditions for the earnings equations given in footnote \#14.
\[ W_t(C_t) = \mu_0 + \mu_1 C_t + \mu_2 C_t^2 + \varepsilon_t \]

where \( L_t \) and \( C_t \) denote hours per year in legitimate and criminal income generating activities respectively, \( S_t \) is the social capital stock accumulated by the individual at the beginning of period \( t \), \( ED_t \) is a categorical variable equal to one if the highest level of education the individual attains is at least a high school diploma and equal to zero otherwise, \( SCH_t \) is a categorical variable equal to one if the individual has not yet completed his education and zero otherwise, and \( \varepsilon_L \) and \( \varepsilon_C \) are random error terms.

We wish to use these equations to make statements regarding the determinants of income for the entire sample of men. However, hours worked in each sector are endogenous, and only a subsample of the population are engaged in (either or both of) the income producing activities, so that the time allocation variables, \( L_t \) and \( C_t \), are censored from below at zero hours. If the decision to work (in legitimate or illegitimate activities) depends on unobservable characteristics which also influence earnings, then the problem of sample selection exists. Since we are estimating the earnings equations separately from the Euler equations, we make use of standard econometric techniques to account for the possibility of sample selection bias. As actual hours worked (in either activity) are observed, we adopt the methodology suggested in Vella (1996)\(^{19}\).

### 3.2 Estimation Methodology for the Euler Equations

To begin, we assume that we have a panel of \( T \) periods of observations on a random sample of \( N \) individuals and that all arguments of the Euler equations are observed without error. Assume that the earnings in the legal sector and crime are

\(^{19}\)This approach is similar to the parametric two-step approach of Heckman (1976,1979). In the first step, we assume normality of the error term in the latent variable reduced form equation for hours worked. However, distributional assumptions about the error term in the earnings equation are relaxed in the second step. This leads us to approximate the selection term in the earnings equation by \( \sum_{i} \varepsilon \hat{\psi} \), where the \( \hat{\psi} \)’s are the generalized residuals from the first step Tobit estimation and \( K \) is the number of terms in the approximating series. By including this polynomial in the earnings equation, we take account of the selection term. Therefore, exploiting the variation in hours worked (in either legitimate or illegitimate income producing activities) for the subsample who participate provides consistent OLS estimates of parameters in the (respective) earnings equation. Provided \( K \) is treated as known, these estimates are \( \sqrt{n} \) consistent and it is straightforward to compute the second step covariance matrix.
parameterized as above and that utility has the following transcendental logarithmic form:

\[ U(X_t, \ell_t, S_t) = \alpha_1 \ln X_t + \alpha_2 \ln \ell_t + \alpha_3 \ln S_t + \frac{1}{2} \left\{ \beta_{11} (\ln X_t)^2 + \beta_{22} (\ln \ell_t)^2 + \beta_{33} (\ln S_t)^2 \right\} + \beta_{12} \ln X_t \ln \ell_t + \beta_{13} \ln X_t \ln S_t + \beta_{23} \ln \ell_t \ln S_t. \]

To simplify exposition of our method for estimating the parameters of the Euler equations we introduce the following notation. Let \( S_t \) denote the value of the state variable, social capital stock, for the \( ith \) individual in period \( t \), \( x_t \) denote the vector of choice variables entering the \( ith \) individual's Euler equations in period \( t \), and let \( x_{t+1} \) be those variables dated \( t+1 \). Each of these Euler equations can be written in the form of \( f_j(x_t, S_t, \theta_0) - g_j(x_{t+1}, S_{t+1}, \theta_0), \) \( j = 1, 2, 3 \), where \( f(\cdot) \) is the observed response function which depends on current period variables, and \( g(\cdot) \) is the expected response function, which depends on next periods variables, and \( \theta_0 \) is the \( pxl \) vector of parameters to be estimated.\(^{20}\) A stochastic framework is introduced by assuming that variables determined outside the model, whose future values are unknown and random, cause agents to make errors in choosing their utility maximizing bundles. These errors are idiosyncratic so that at any point in time, the expectation of this disturbance term over individuals is zero. We also assume that these disturbances are independently distributed over time and represent the \( ith \) individual's system of equations as:

\[ f(x_t, S_t, \theta_0) - g(x_{t+1}, S_{t+1}, \theta_0) = u_t. \]

\(^{20}\) We take the estimated earnings equation parameters to be the true values, and the parameters governing the law of motion for social capital accumulation to be those obtained using principal components. This is discussed in depth in the next section. Sample data is used to calibrate the probability of arrest at 0.06. We assume a real rate of interest of 3%, and a time rate of preference of 0.95. Substituting these parameters, the derivatives of the income functions and the translog utility functions into the Euler equations from Section 2 results in the representative individual's per period optimal choice of time allocations \((L, C)\) and consumption \((X)\) parameterized by \( \theta_0 = (\alpha, \alpha_1, \alpha_2, \beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6) \).
Suppose there exist conditional moment restrictions of the form, \( E[u_n | z_u] = 0 \), where \( z_u \) are observed data. These moment restrictions can be used to form a nonlinear instrumental variables estimator of the preference parameters (Amemiya (1974), Jorgenson and Laffont (1974), and Gallant (1977)). Given panel data covering \( T \) years for each of the \( N \) individuals, the population orthogonality conditions can be written as:

\[
E_N \left[ \frac{1}{T} \sum_{t=1}^{T} \left( f(x_{u,t}, S_{u,t}, \theta_0) - g(x_{u+1,t}, S_{u+1,t}, \theta_0) \right) \otimes z_u \right] = E_N \left[ M(x_t, S_t, z_t, \theta_0) \right] = 0.
\]

Suppose then a law of large numbers can be applied to \( M(x_t, S_t, z_t, \theta_0) \) for all admissible \( \theta \), so that the mean of \( M(x_t, S_t, z_t, \theta_0) \) converges to its population mean.

\[
\lim_{N \to \infty} \frac{1}{N} \sum_{i=1}^{N} M(x_t, S_t, z_t, \theta_0) = E_N \left[ M(x_t, S_t, z_t, \theta_0) \right].
\]

Hansen (1982) points out that the NLIV estimator of this form can be interpreted as the Generalized Method of Moments estimator when the \( u_n \) are serially uncorrelated and conditionally homoskedastic. Under the regularity conditions outlined in Hansen, (1982), the GMM estimator \( \theta_{MM} \), of the unknown parameter vector \( \theta_0 \) minimizes the generalized quadratic distance from zero of the empirical moments:

\[
\left[ \frac{1}{N} \sum_{i=1}^{N} M(x_t, S_t, z_t, \theta_0) \right] \otimes W_N \left[ \frac{1}{N} \sum_{i=1}^{N} M(x_t, S_t, z_t, \theta_0) \right]^{-1}
\]

where \( W_N \) is a symmetric positive definite weighting matrix which satisfies:

\[
\lim_{N \to \infty} W_N \xrightarrow{a.s.} W_0 \]

21 The choice of weighting matrix that produces the efficient or optimal GMM estimator is \( W_0 = \Omega^{-1} \), where \( \Omega^{-1} \) is consistently estimated by \( \Omega_N^{-1} = \frac{1}{N} \sum_{i=1}^{N} [u_i \otimes z_i] [u_i \otimes z_i]' \)
In practice, implementing GMM as an estimator for the parameters in our system of Euler equations is hampered by the fact that observed future welfare is state contingent, while agents’ decisions are based on ex-ante expectations of the future. For those who engage in crime, there are two possible future states of the world - apprehension and escaping apprehension. Ex-post, only one state is realized for each individual and subsequently observed by the econometrician. Since the (unobserved) choice in the state not realized enters the Euler equations through \( g(x_{it+1}, S_{it+1}, \theta_0) \), we are faced with an omitted regressor problem in the expected response function. We resolve this problem by replacing \( M(.) \) with a simulator, \( \mu(.) \). McFadden (1989) proposes this simple modification of the conventional Method of Moments estimator as the basis for the Method of Simulated Moments\(^{22}\).

To illustrate our use of MSM, suppose that we are have one Euler equation, and there is one choice variable, \( x_{it} \). Recall that individual \( i \)'s current choice \( x_{it} \) depends on the value of the state variable, social capital stock, \( S_{it} \). Our problem is that \( x_{it+1} \) is not observed for individual \( i \) in the state not realized in period \( t+1 \), so sample averages of \( M(.) \) cannot be formed. However, if the density, \( \Pi(x, S) \) is stationary, then we can replace the unobserved \( x_{it+1} \) with Monte-Carlo draws from the conditional distribution, \( \Pi(x|S_{it+1}) \)\(^{23}\). Since this distribution is unknown, we draw from the empirical conditional distribution, which is estimated by kernel-based methods. Having replaced the unobserved data with the Monte-Carlo draws, we then form a simulator of our moment conditions as follows

\[
\frac{1}{T} \sum_{t=1}^{T} \left[ \frac{1}{S} \sum_{s=1}^{S} \left( f(x_{is}, S_{is}, \theta_0) - g(x_{is+1, t}, S_{is+1}, \theta_0) \right) \otimes z_{is} \right] = \mu(x_{i}, S_{i}, z_{i}, \theta_0)
\]

\(^{22}\)Sufficient conditions for the MSM estimator to be consistent and asymptotically normal involve the same regularity assumptions and conditions on instruments as classical GMM, in addition to the two following assumptions that concern the simulator, \( \mu(.) \): (i) the simulation bias, conditional on \( W_\theta \) and \( x_{it} \), is zero, and (ii) the simulation residual process is uniformly stochastically bounded and equicontinuous in \( \theta \).

\(^{23}\)Recall that \( S_{it+1} \) depends on last periods choices, and whether or not the individual is apprehended in period \( t+1 \). So we are able to construct future social capital stock in period \( t+1 \) in the unobserved state.
\[ \lim_{K \to \infty} E_{\mu} \left[ \frac{1}{N} \sum_{i=1}^{N} \left[ \mu \left( x_i, S_i, z_i, \theta_0 \right) \right] \right] = E_{\mu} \left[ M \left( x_i, S_i, z_i, \theta_0 \right) \right] \]

Generalizing to three Euler equations and three unobserved choices, we use this framework to form a simulator of the moment conditions and obtain an estimator for the preference parameters by minimizing the weighted quadratic distance of the simulated moments from zero. Note that, although we motivate our estimation methodology as a way of dealing with uncertainty about future states, our use of simulation techniques that are conditioned on individual characteristics may also be viewed as a partial control for unobserved individual heterogeneity about those states.

4. DATA

4.1 Description of the 1958 Philadelphia Birth Cohort Study

We empirically implement our model using data from the 1958 Philadelphia Birth Cohort Study (Wolfgang, Figlio and Tracy, 1988). This data presents a unique opportunity to study the dynamic decision to participate in crime. Data used to study crime at the individual level are generally drawn from high risk populations, such as prison releasees, and consequently suffer from selection bias. The 1958 Philadelphia Birth Cohort Study has a universe of all individuals born in 1958 who lived in Philadelphia at least from their tenth until their eighteenth birthday. Since all individuals in the sample are the same age and lived in the same city during their adolescent years, this data set is especially suited to studying dynamic elements of individuals' preferences.

Public and parochial school records were used to identify the 27,160 subjects who met the criteria of being born in 1958 and living in Philadelphia between the ages ten through eighteen. Juvenile and adult arrest records up to age 26 were collected for the cohort members. Rap sheet and police investigation reports provided by the Juvenile Aid Division of the Philadelphia Police Department were used to characterize all police encounters experienced by the cohort before age eighteen. The adult criminal justice data come from the Municipal and Common Pleas Courts of
Philadelphia. These data include rap sheet information on every offense committed in Philadelphia by cohort members who were eighteen years of age or older up until December 31, 1984.

In the final stage of the Study the cohort was stratified by gender, race, socioeconomic status, and number of juvenile offenses. A random sample was selected from each strata for a follow-up survey that was carried out in 1988. Between 30 and 40 percent of the members in each category were ultimately interviewed\textsuperscript{25}. Importantly for our analysis, the follow-up survey contains self-report data on criminal and labor market activity\textsuperscript{26}. We use the self-report data on criminal activity covering ages nineteen to twenty-four, corresponding to the six year sample 1977 to 1982. Detailed information on individual’s employment history was also collected as part of the follow-up survey\textsuperscript{27}. This information was used to construct annual observations on the number of hours worked per year and annual labor income from legitimate labor market activities. Our final data set contains observations on 423 individuals over the ages of 19-24 corresponding to the period 1977 to 1982. A definition of variables can be found in Appendix 2 and summary statistics in Table 1.

4.2. Measuring Social Capital

In this section, we outline the procedure for constructing the key variable of our dynamic model of crime, social capital. We begin with construction of the initial level of social capital stock.

Each individual will enter the study period with some initial level of social capital stock, \( S_0 \), which has been accumulated through childhood up until the end of 1976, the year he turns eighteen. The initial level of social capital represents the stock in society that is inherited from one’s family. The empirical literature suggests that this stock is

\textsuperscript{24} This term refers to an individual’s criminal history.

\textsuperscript{25} Figlio (1994) reports that comparisons among the strata indicate no apparent biases due to nonparticipation.

\textsuperscript{26} Although telescoping, lack of recall, and candor are all possible in retrospective studies of this type, Figlio (1994) finds no evidence of uniform telescoping bias.
determined by factors which relate to the transmission of norms and values from parents to children, and the receptiveness of children to this transmission. Family structure and the children's attachment to youth culture are particularly important to this process. The 1958 Philadelphia Birth Cohort Study contains data on these factors. The information contained in the data is summarized in a composite index using the method of principal components.\footnote{Since the objective of applying principal component analysis to the data is to obtain weights reflective of the relative importance of these factors in accumulating social capital, we base our analysis on the covariance matrix method, and use weights from the first principal component. Table 2 lists the variables used in the construction of the initial level of social capital, \( S_0 \), and the corresponding weights arising from principal component analysis.}

The weights are signed as expected. Coming from a white two-parent household with a high socioeconomic status and having a father with no arrests during the individual's childhood increases the stock in society inherited from the family. Our results indicate that not being involved in a (deviant) youth culture, such as a gang, and having friends who were not in trouble with the police facilitates the transmission of social capital from the family. We find support for the hypotheses that siblings dilute parental attention, which negatively affects the transmission of social capital from family to child. We also find that involvement in criminal activity in youth, as measured by juvenile arrests, reduces the stock in society inherited from one's family.

Having obtained each individual's initial level of social capital, subsequent periods' stocks are constructed according to the stock accumulation equations 2.3 and 2.4. In

\footnote{In particular, for each job (whose tenure was at least six months), wage income when the individual began and ended employment, whether the job was part time or full time, the pay period (hourly, weekly, monthly, or yearly), and the average hours worked per week, were recorded.}

\footnote{The principal component series are constructed by taking a weighted sum of the original variables, the weights being the elements of the characteristic vectors of the covariance matrix of the original variables. Since the objective is to obtain a one dimensional representation of all the variables under consideration, only the first principal component is used.}

\footnote{This method requires variables to be of a similar scale. However, the average annual number of hours spent at work or in crime are orders of magnitude larger than the index of initial social capital stock and categorical variables. Therefore, we rescale the initial level of capital stock and dummy to be of a comparable magnitude.}
our empirical specification, we allow a broader interpretation of legitimate activities as investment in social capital. In particular, we allow marital status \( (M_t) \) and the beginning a new job \( (J_t) \) to build stock in society. An initial set of parameter estimates for each of our stock accumulation equations are obtained by performing principal component analysis on initial period data, including \( S_0 \), for individuals who experienced the corresponding state of nature. The parameter estimates are updated yearly, as observations on social capital are calculated. To filter out the variation in parameters arising from this iterative procedure, we perform the following regression to obtain our final set of weights.

\[
S_{t+1} = k + (1 - \delta)S_t + \gamma_1 L_t (1 - I_t) + \gamma_2 M_t (1 - I_t) + \gamma_3 J_t (1 - I_t) - \alpha C_t S_t I_t + u_t
\]

where \( I_t \) is an indicator equal to 1 if the individual is arrested in period \( t \), and 0 otherwise. The resulting weights are shown in Table 3. These are used to construct our series of social capital stock.

These results imply a rate of depreciation on social capital of 3% a year. If apprehended, and assuming the average time spent in crime (for those arrested) of 129 hours per year, the penalty is a further loss of 3% of social capital. Time spent in employment, getting married, and changing jobs all have a positive impact on creating stock in society, as expected, while being arrested incurs a penalty, as indicated by the negative coefficient the interaction between time in crime and social capital stock.

5. ESTIMATION RESULTS

5.1 Earnings Equation Results

The earnings equations for criminal and legitimate activities are estimated using a fourth order polynomial in the respective generalized Tobit residuals to approximate the correlation between the error terms of the selection and earnings equations. The results of this estimation are given below in Table 4.

The parameter estimates for earnings in legitimate labor market activities are consistent with the standard predictions of human capital theory. Legitimate earnings
are a concave function of time spent in that activity. The accumulation of human capital\textsuperscript{30} (having at least a high school education) results in an income profile with a lower starting income and a steeper slope. In addition to the human capital theory of earnings, we find evidence state dependence working through social capital. As an investment good, representing institutional knowledge and networks, social capital has a positive (and significant) impact on earnings. Assuming the mean level of social capital over the sample, the magnitude of this affect is the same as that associated with achieving a high school degree or better. This result supports the hypothesis that market earnings exhibit state dependence in nondeviant behavior, as measured by the social capital accumulation process, and that both human and social capital are significant determinants of earnings.

Annual income from crime is found to be an increasing function of time spent in that activity. Increasing returns to time in crime may be evidence of some fixed cost, or accumulation of crime specific networks and knowledge.

One of the more salient features of the earnings equations results is that criminals and noncriminals do not differ markedly in their earning ability in the legal sector, as seen in Table 5. Contrary to the prediction of the traditional economic model of crime\textsuperscript{31}, it does not appear that lower earning ability in legitimate activities leads to participation in crime. Our result may be reflective of the youth of our sample and the short period of labor market time observed after the completion of (higher) education. Nonetheless, this finding is consistent with a large body of empirical research that fails to find a significant relationship between wages (or income) and criminal activity.\textsuperscript{32}

Another revealing feature of our results is that income from crime displays increasing returns while income from legitimate work displays diminishing returns to time spent in the respective activity. From this characterization of earnings profiles we would

\textsuperscript{30} See footnote 11.
\textsuperscript{31} Ehrlich’s (1973) time allocation model of crime predicts that a relative increase in legal wages will reduce the incentive to participate in illegal activity.
expect individuals who participate in crime to specialize. However, eighty percent of men in our sample who engage in crime also work in the legitimate sector. Further, criminals only spend an average of one and one-half hours per week in crime compared to almost 36 hours per week working at a legitimate job. This implies there are costs associated with crime, or benefits associated with not engaging in crime, that are not captured by the earnings equations. According to our model, these benefits are the utility value of social capital, such as social acceptance and reputation, representing state dependence in nondeviant behavior in the preference structure. We test this hypothesis in the next section by estimating the Euler equations associated with optimal allocation of time to criminal and legitimate activities, and consumption.

5.2 Euler Equation Results
The system of Euler equations derived in Section 2 is estimated using MSM on 423 individual's over the period 1977 to 1981. The coefficient on the logarithm of social capital is normalized at unity, leaving eight coefficients to be estimated. With three equations and eleven instruments, the number of overidentifying restrictions is twenty-five. The Hansen test statistic for overidentifying restrictions is 5.23, compared to a $\chi^2_{0.95,25} =37.65$, leading us to accept the null hypothesis that the system is overidentified. The SMM estimates of the preference parameters are presented in Table 6. Seven of the eight coefficients are found to be statistically significant. It is noteworthy that all three terms involving social capital are found to be significantly different from zero, supporting the hypothesis that preferences exhibit state dependence.

Examining the estimates of the translog preference parameters in Table 6, we find the coefficients on the interaction terms between consumption and leisure ($\ln X, \ln \ell$), consumption and social capital ($\ln X, \ln S$), and leisure and social capital ($\ln \ell, \ln S$) all are significant. This indicates that utility is not contemporaneously separable in any of its arguments. Nonseparability between consumption and leisure is an important finding as separability is often assumed. Our estimates imply that consumption and leisure are compliments in utility. This is consistent with the work

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33 This represents an average for those working.
of Hotz, Kydland and Sedlacek (1988), and Sickles and Yazbeck (1997). The relationships between consumption and social capital, and leisure and social capital are also found to be complementary.

Table 7 shows that our estimated marginal utility of consumption, leisure, and social capital are positive for all time periods. We find that the value of an incremental increase in the consumption good rises over the life-course for our sample of young men. In contrast, the marginal utility of leisure declines steeply between the ages of nineteen and twenty, but remains fairly steady thereafter. Based on these estimates, the average marginal rate of substitution of is 0.0725, implying an hourly wage of $5.42 over the sample period. The marginal rate of substitution of consumption for leisure we find in studying youth is about an order of magnitude smaller than the value of 0.8667 obtained by Sickles and Yazbeck who use data from the Retirement History Survey. This may be evidence that individuals place a higher value on leisure time as they draw closer to the end of their lives.

Table 7 also shows that the marginal utility of social capital increases over the life-cycle for our sample of young men. In addition to growing state dependence, this result indicates that agents are indeed forward looking in their decision making. Over the sample period, average leisure time decreases as individuals spend a greater amount of time in employment. Current labor market activity is expected to increase future welfare through social capital accumulation process, and this in turn raises the marginal utility of social capital in the current period. Thus, the marginal utility of past investment in social capital is increasing in current investment. Alternately, the marginal utility of current investment in social capital is increasing in past investment. This is a necessary condition for adjacent complementarity. Since past labor market participation raises social capital stock, which raises future labor supply, we also find reinforcement in decision making.

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34 Other studies, however, find evidence that these goods are substitutes (Altonji, 1986; Ghez and Becker, 1975; Thow, 1969)).
35 These are obtained by evaluating at sample averaged (across individuals) data.
36 This number is calculated by multiplying the marginal rate of substitution by the CPI, where the CPI is averaged over 1977 to 1981.
37 See Heal and Ryder (1973) and Becker and Murphy (1988).
To gauge the relative importance of consumption, leisure, and social capital in terms of utility value, we consider the elasticity of utility with respect to each of these arguments. This is presented in Table 8. These results indicate that utility is most sensitive to changes in social capital and least responsive to changes in consumption. It is also interesting to note the temporal pattern in these elasticities. As these individuals age, their welfare becomes more responsive to changes in their level of social capital and consumption, and less responsive to changes in their level of leisure. This finding is further support of growing state dependence in preferences.

Recall that our hypothesis is that institutional relationships such as marriage and a 'good' job strengthen an individual's stock in society. This has the affect of increasing the cost of translating criminal propensities into crime, thereby making the occurrence of crime less likely. This life-cycle model of behavior is consistent with the pattern of criminal behavior observed in the age-crime profile. It is particularly revealing to compare the temporal pattern of the age-crime profile of the cohort to which our sample belongs, with the profile of marginal utility of social capital for the sample. Figure 1 shows a strong inverse relationship between the two profiles. Our results provide evidence of growing state dependence and reinforcement in nondeviant behavior, and hence increasing costs of deviant behavior, during a period of decline in participation in crime. We therefore conclude that our model provides a possible explanation for the empirical phenomenon of age-crime profile.

Our model performs well at explaining the decline in participation in crime for the average of our sample and our results raise the question of whether differences in the degree to which individuals are 'at risk' determines criminal participation. Our index of social capital allows us to investigate this issue, since it provides a measure for unobserved deviant propensity. In particular, family background and childhood variables used in the construction of the initial level of social capital stock are commonly used as indicators of whether an individual is at risk of criminality.\textsuperscript{38}

\textsuperscript{38} We investigate the ability of this measure to predict the probability of an individual participating in crime in Williams and Sickles, 1997b.
Our investigation proceeds by partitioning the sample into quartiles on the basis of initial period social capital stock and comparing the temporal pattern in the marginal utility of social capital for the first and fourth quartiles. These groups represent the most and least 'at risk' individuals respectively. Figure 2 shows that the marginal utility of social capital for individuals in the fourth quartile (low risk group) increases over time, just as it does for the whole sample.

The marginal utility of social capital for individuals from the first quartile (high risk group) displays a markedly different temporal pattern, as shown in Figure 3. While the value of an incremental increase in social capital increases over the ages 19 to 21, it falls thereafter.

Also, the marginal utility of social capital is always negative for this group. The latter finding may be an artifact of the assumed functional form for utility. Alternatively, it may be revealing something of a more behavioral nature.

On comparing the two groups' involvement with the criminal justice system, we find that individuals from the first quartile are far more likely to be arrested for an income producing crime in any year. This is reported in Table 9. These men appear to be embedded in a criminal culture by the age of 18, when our study begins, and may consider social capital to hinder their advancement in such a culture. This interpretation is consistent with a negative marginal utility associated with social capital. While state dependence in crime appears to diminish over the age of 19 to 21, as indicated by marginal utility of social capital becoming less negative, it strengthens thereafter. This could be evidence of the difficulty these individuals have breaking free from state dependence in criminal culture and successfully building stock in legitimate society.

\footnote{The translog frees up constraints on additivity and homotheticity, which makes it better behaved in terms of global curvature properties than more restrictive functional forms. However, this flexibility often compromises the regularity of the estimated curvatures outside the region in which the data and estimates are centered. This problem has been well documented in the literature of flexible functional forms (Guilkey, et al., 1983; Pollak, et al., 1984; Barnett, 1985; Dievert and Wales, 1987).}
Our findings suggest that differences in the level of social capital inherited from the family may explain why some individuals become career criminals, while others experience relatively short careers in crime. In particular, failure of parents to pass on a critical level of stock in society may increase the likelihood of children becoming career criminals in adulthood.

6. CONCLUSION

In this paper we integrate the intertemporal choice and economics of crime literature to develop a dynamic model of criminal choice. Our model assumes that an individual’s preferences and earnings are influenced by his stock of social capital. Since agents anticipate the future consequences of their actions through the capital accumulation process, rationality is forward looking.

Our model of rational criminal choice predicts that people who are more attached to the labor force and have a cohesive marriage develop a state dependence that reduces the likelihood of criminal involvement. We measure this state dependence using an index of social capital stock. Further, we allow for differences arising from observable family background to determine the initial value of this index.

We find strong empirical support for our dynamic model of crime. The selectivity corrected earnings equation estimates for labor market activities supports both human and social capital theories of earnings. Consistent with the human capital theory, we find that human capital raises labor market earnings. We also find that earnings are increasing in social capital stock. This provides evidence of the monetary value of networks and institutional knowledge that result from investment in one’s society. Moreover, the magnitude of the return to social capital is equal to the earnings premium associated with investment in education.

Although both human and social capital are found to have a positive impact on labor market earnings, we do not find that criminals and noncriminals differ markedly in their earnings ability, as measured by their estimated hourly wage rate. This result may be attributed to the youth of our sample, and the short period of time observed after the completion of (higher) education. Nonetheless, it is consistent with a large
body of empirical literature that fails to find a significant relationship between wages (or income) and crime.

Application of a simulated method of moments estimator to our system of Euler equations reveals significant state dependence in preferences, as measured by the stock of social capital. We find that the marginal utility of past investment in social capital is increasing in current investment, implying adjacent complementarity. This leads to growing state dependence over the life-course. Growing state dependence in nondeviant behavior raises the potential cost of engaging in crime, making its occurrence less likely. Therefore, we find that our model provides an explanation of the empirical relationship between aggregate arrests and age.

We also investigate the performance of our model across individuals who differ in their degree of being 'at risk' of becoming criminals. Our index of social capital allows us to explore this issue since it provides a measure of propensity for crime. Our findings suggest that low levels of social capital inherited from the family may explain why some individuals become career criminals, while individuals who are more richly endowed experience relatively short careers in crime. Also evident from our results is the dynamic nature of the process of criminal choice. The late teenage years to early twenties is a crucial time for making the transition out of crime, even for those most disadvantaged in terms of inherited social capital stock.
REFERENCES


Beccaria, C., On Crimes and Punishments (Indianapolis: Bobbs-Merril, 1963 [1764]).


## Table 1
**Descriptive statistics**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>$L_t$</td>
<td>1,566.22</td>
<td>897.40</td>
</tr>
<tr>
<td>$C_t$</td>
<td>75.24</td>
<td>197.90</td>
</tr>
<tr>
<td>$I_t$</td>
<td>4,182.54</td>
<td>891.56</td>
</tr>
<tr>
<td>$X_t$</td>
<td>125.29</td>
<td>86.01</td>
</tr>
<tr>
<td>$S_t$</td>
<td>96.56</td>
<td>19.55</td>
</tr>
<tr>
<td>$W_t$</td>
<td>102.31</td>
<td>94.25</td>
</tr>
<tr>
<td>$W_C$</td>
<td>3.63</td>
<td>16.83</td>
</tr>
<tr>
<td>DAD</td>
<td>0.82</td>
<td>0.39</td>
</tr>
<tr>
<td>DAI</td>
<td>0.11</td>
<td>0.31</td>
</tr>
<tr>
<td>SIBS</td>
<td>3.27</td>
<td>2.17</td>
</tr>
<tr>
<td>WHITE</td>
<td>0.56</td>
<td>0.50</td>
</tr>
<tr>
<td>SES</td>
<td>0.54</td>
<td>0.50</td>
</tr>
<tr>
<td>GANGLT18</td>
<td>0.29</td>
<td>0.45</td>
</tr>
<tr>
<td>MATEBOOK</td>
<td>1.43</td>
<td>1.36</td>
</tr>
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<td>ARCON</td>
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<td>0.39</td>
</tr>
<tr>
<td>M</td>
<td>0.05</td>
<td>0.23</td>
</tr>
<tr>
<td>J</td>
<td>0.10</td>
<td>0.30</td>
</tr>
<tr>
<td>ED</td>
<td>0.66</td>
<td>0.47</td>
</tr>
<tr>
<td>SCHOOL</td>
<td>0.15</td>
<td>0.36</td>
</tr>
</tbody>
</table>

## Table 2
**Construction of the Initial Stock of Social Capital**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>father present in childhood home</td>
<td>0.15</td>
</tr>
<tr>
<td>father not arrested during childhood</td>
<td>0.07</td>
</tr>
<tr>
<td>number of siblings</td>
<td>-0.04</td>
</tr>
<tr>
<td>race is white</td>
<td>0.25</td>
</tr>
<tr>
<td>socioeconomic-economic status is high</td>
<td>0.29</td>
</tr>
<tr>
<td>not a gang member</td>
<td>0.28</td>
</tr>
<tr>
<td>proportion of best 3 friends from high school not picked up by the police</td>
<td>0.18</td>
</tr>
<tr>
<td>proportion of police contacts as a juvenile that result in arrest</td>
<td>-0.18</td>
</tr>
</tbody>
</table>
## Table 3

*Construction of the Stock of Social Capital*

<table>
<thead>
<tr>
<th>Variable</th>
<th>Co-efficient</th>
<th>Standard Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>constant</td>
<td>-60.07</td>
<td>22.23</td>
</tr>
<tr>
<td>$S_t$</td>
<td>0.97</td>
<td>0.0023</td>
</tr>
<tr>
<td><strong>Not Arrested</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$L_t$</td>
<td>0.08</td>
<td>0.0046</td>
</tr>
<tr>
<td>$M_t$</td>
<td>0.07</td>
<td>0.0036</td>
</tr>
<tr>
<td>$J_t$</td>
<td>0.26</td>
<td>0.0027</td>
</tr>
<tr>
<td><strong>Arrested</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$C_{S_t}$</td>
<td>-0.00021</td>
<td>0.000083</td>
</tr>
</tbody>
</table>

## Table 4

*Selectivity Corrected Estimates of the Earnings Equations* $^a$

<table>
<thead>
<tr>
<th>Variable</th>
<th>Work</th>
<th>Crime</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONSTANT</td>
<td>0.5936</td>
<td>0.1849</td>
</tr>
<tr>
<td></td>
<td>(0.035)</td>
<td>(0.228)</td>
</tr>
<tr>
<td>HOURS$_t$</td>
<td>0.0702</td>
<td>0.0189</td>
</tr>
<tr>
<td></td>
<td>(4.22)</td>
<td>(0.786)</td>
</tr>
<tr>
<td>HOURS$_t^2$</td>
<td>-1.985*10$^6$</td>
<td>5.4316*10$^5$</td>
</tr>
<tr>
<td></td>
<td>(-4.99)</td>
<td>(2.822)</td>
</tr>
<tr>
<td>$L_t$*$S_t$</td>
<td>0.00010</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(1.954)</td>
<td></td>
</tr>
<tr>
<td>ED</td>
<td>-19.58</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(-1.586)</td>
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</tr>
<tr>
<td>$L_t$*$ED$</td>
<td>0.011</td>
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</tr>
<tr>
<td></td>
<td>(1.758)</td>
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</tr>
<tr>
<td>SCHOOL</td>
<td>-1.1604</td>
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</tr>
<tr>
<td></td>
<td>(-0.207)</td>
<td></td>
</tr>
<tr>
<td>$v$</td>
<td>-2.7630*10$^1$</td>
<td>1.2314*10$^2$</td>
</tr>
<tr>
<td></td>
<td>(-0.350)</td>
<td>(0.272)</td>
</tr>
<tr>
<td>$v^2$</td>
<td>5.0240*10$^6$</td>
<td>1.2172*10$^8$</td>
</tr>
<tr>
<td></td>
<td>(0.896)</td>
<td>(0.121)</td>
</tr>
<tr>
<td>$v^3$</td>
<td>-1.2586*10$^9$</td>
<td>-5.0680*10$^8$</td>
</tr>
<tr>
<td></td>
<td>(-0.389)</td>
<td>(-0.124)</td>
</tr>
<tr>
<td>$v^4$</td>
<td>-1.4990*10$^{12}$</td>
<td>1.5611*10$^{11}$</td>
</tr>
<tr>
<td></td>
<td>(-0.936)</td>
<td>(0.738)</td>
</tr>
</tbody>
</table>

$^a$ Figures in parentheses are t-ratios.
Table 5
Estimated Average Hourly Wage in Crime\textsuperscript{40} and Work

<table>
<thead>
<tr>
<th>Year</th>
<th>Criminal</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Crime</td>
<td>Work</td>
<td>Crime</td>
<td>Work</td>
<td></td>
</tr>
<tr>
<td>77</td>
<td>3.74</td>
<td>4.59</td>
<td>3.95</td>
<td>4.63</td>
<td></td>
</tr>
<tr>
<td>78</td>
<td>3.63</td>
<td>4.95</td>
<td>3.39</td>
<td>5.03</td>
<td></td>
</tr>
<tr>
<td>79</td>
<td>3.24</td>
<td>5.52</td>
<td>3.65</td>
<td>5.59</td>
<td></td>
</tr>
<tr>
<td>80</td>
<td>3.79</td>
<td>6.29</td>
<td>4.66</td>
<td>6.37</td>
<td></td>
</tr>
<tr>
<td>81</td>
<td>4.12</td>
<td>6.91</td>
<td>4.74</td>
<td>7.03</td>
<td></td>
</tr>
</tbody>
</table>

Table 6
Parameter Estimates and Standard Errors For the Translog Utility Function

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Standard Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>(lnX_t)</td>
<td>0.2256</td>
<td>0.00053</td>
</tr>
<tr>
<td>(ln\ell_t)</td>
<td>0.2061</td>
<td>0.31388</td>
</tr>
<tr>
<td>((lnX_t)^2)</td>
<td>0.0007</td>
<td>0.0000041</td>
</tr>
<tr>
<td>((ln\ell_t)^2)</td>
<td>0.1084</td>
<td>0.036354</td>
</tr>
<tr>
<td>((lnS_t)^2)</td>
<td>0.1910</td>
<td>0.054218</td>
</tr>
<tr>
<td>(lnX_t ln\ell_t)</td>
<td>-0.0220</td>
<td>0.000764</td>
</tr>
<tr>
<td>(lnX_t lnS_t)</td>
<td>-0.0077</td>
<td>0.001432</td>
</tr>
<tr>
<td>(lnS_t ln\ell_t)</td>
<td>-0.2141</td>
<td>0.028430</td>
</tr>
</tbody>
</table>

\textsuperscript{40} Criminals are considered to be all individuals who were arrested at least once during the period 1976-1984.
### Table 7

**Marginal Utility of Consumption, Leisure and Social Capital**
*(evaluated at sample averages)*

<table>
<thead>
<tr>
<th>Age</th>
<th>Consumption</th>
<th>Leisure</th>
<th>Social Capital</th>
</tr>
</thead>
<tbody>
<tr>
<td>19</td>
<td>$8.13 \times 10^{-5}$</td>
<td>$7.17 \times 10^{-6}$</td>
<td>$4.29 \times 10^{-4}$</td>
</tr>
<tr>
<td>20</td>
<td>$7.70 \times 10^{-5}$</td>
<td>$5.87 \times 10^{-6}$</td>
<td>$5.08 \times 10^{-4}$</td>
</tr>
<tr>
<td>21</td>
<td>$7.98 \times 10^{-5}$</td>
<td>$5.59 \times 10^{-6}$</td>
<td>$5.54 \times 10^{-4}$</td>
</tr>
<tr>
<td>22</td>
<td>$8.24 \times 10^{-5}$</td>
<td>$5.79 \times 10^{-6}$</td>
<td>$5.69 \times 10^{-4}$</td>
</tr>
<tr>
<td>23</td>
<td>$8.43 \times 10^{-5}$</td>
<td>$5.88 \times 10^{-6}$</td>
<td>$5.83 \times 10^{-4}$</td>
</tr>
</tbody>
</table>

---

### Table 8

**Responsiveness of Utility to a 1% Increase in Consumption, Leisure and Social Capital**
*(evaluated at each data point and averaged over individuals)*

<table>
<thead>
<tr>
<th>Year</th>
<th>Consumption</th>
<th>Leisure</th>
<th>Social Capital</th>
</tr>
</thead>
<tbody>
<tr>
<td>19</td>
<td>$2.11 \times 10^{-3}$</td>
<td>$8.15 \times 10^{-3}$</td>
<td>$1.08 \times 10^{-2}$</td>
</tr>
<tr>
<td>20</td>
<td>$2.59 \times 10^{-3}$</td>
<td>$6.31 \times 10^{-3}$</td>
<td>$1.25 \times 10^{-2}$</td>
</tr>
<tr>
<td>21</td>
<td>$2.68 \times 10^{-1}$</td>
<td>$5.84 \times 10^{-3}$</td>
<td>$1.36 \times 10^{-2}$</td>
</tr>
<tr>
<td>22</td>
<td>$2.76 \times 10^{-1}$</td>
<td>$5.99 \times 10^{-3}$</td>
<td>$1.38 \times 10^{-2}$</td>
</tr>
<tr>
<td>23</td>
<td>$2.84 \times 10^{-1}$</td>
<td>$6.01 \times 10^{-3}$</td>
<td>$1.41 \times 10^{-2}$</td>
</tr>
</tbody>
</table>
### Table 9

**Arrests for First and Fourth Quartiles**

<table>
<thead>
<tr>
<th>Year</th>
<th>Total (all quartiles)</th>
<th>First Quartile (proportion)</th>
<th>Fourth Quartile (proportion)</th>
</tr>
</thead>
<tbody>
<tr>
<td>77</td>
<td>36</td>
<td>0.33</td>
<td>0.08</td>
</tr>
<tr>
<td>78</td>
<td>26</td>
<td>0.46</td>
<td>0.04</td>
</tr>
<tr>
<td>79</td>
<td>29</td>
<td>0.45</td>
<td>0.10</td>
</tr>
<tr>
<td>80</td>
<td>20</td>
<td>0.40</td>
<td>0.10</td>
</tr>
<tr>
<td>81</td>
<td>23</td>
<td>0.57</td>
<td>0.09</td>
</tr>
</tbody>
</table>

### Figure 1.

*The Marginal Utility of Social Capital Versus the Age Crime Profile*
Figure 2.
The Marginal Utility of Social Capital for the Fourth Quartile

Figure 3.
The Marginal Utility of Social Capital for the First Quartile
Appendix I

We now derive the Euler equations for the social capital model of crime. To begin, take first order conditions.

\[
\frac{\partial V(A_{t}, S_{t})}{\partial X_{t}} = U_1(t) - \beta(l + r) \left\{ p \frac{\partial V(A_{t+1}, S_{t+1}^1)}{\partial A_{t+1}} + (1 - p) \frac{\partial V(A_{t+1}, S_{t+1}^0)}{\partial A_{t+1}} \right\} = 0 \tag{A.1}
\]

\[
\frac{\partial V(A_{t}, S_{t})}{\partial L_{t}} = -U_2(t) + \beta \gamma(l + r) \frac{\partial V(A_{t+1}, S_{t+1}^0)}{\partial S_{t+1}}
+ \beta(l + r) \frac{\partial W_{L}(L_{t}, S_{t})}{\partial L_{t}} \left\{ p \frac{\partial V(A_{t+1}, S_{t+1}^1)}{\partial A_{t+1}} + (1 - p) \frac{\partial V(A_{t+1}, S_{t+1}^0)}{\partial A_{t+1}} \right\} = 0 \tag{A.2}
\]

\[
\frac{\partial V(A_{t}, S_{t})}{\partial C_{t}} = -U_2(t) - \alpha \beta S_{t} \frac{\partial V(A_{t+1}, S_{t+1}^1)}{\partial S_{t+1}}
+ \beta(l + r) \frac{\partial W_{C}(C_{t})}{\partial C_{t}} \left\{ p \frac{\partial V(A_{t+1}, S_{t+1}^1)}{\partial A_{t+1}} + (1 - p) \frac{\partial V(A_{t+1}, S_{t+1}^0)}{\partial A_{t+1}} \right\} = 0 \tag{A.3}
\]

To obtain the Euler equation for \( X_t \), we invoke the envelope theorem to solve out for the partial derivatives of the value function. By the envelope theorem:

\[
\frac{\partial V(A_{t}, S_{t})}{\partial A_{t}} = \beta(l + r) \left\{ p \frac{\partial V(A_{t+1}, S_{t+1}^1)}{\partial A_{t+1}} + (1 - p) \frac{\partial V(A_{t+1}, S_{t+1}^0)}{\partial A_{t+1}} \right\} \tag{A.4}
\]

Substituting (A.1) into (A.4), we have:

\[
\frac{\partial V(A_{t}, S_{t})}{\partial A_{t}} = U_1(t) \tag{A.5}
\]

Updating (A.5) one period:

\[
\frac{\partial V(A_{t+1}, S_{t+1})}{\partial A_{t+1}} = U_1(t + 1) \tag{A.6}
\]

Evaluating (A.6) at \( S_{t+1}^1 \) and \( S_{t+1}^0 \), we obtain (A.7) and (A.8) respectively.

\[
\frac{\partial V(A_{t+1}, S_{t+1}^1)}{\partial A_{t+1}} = U_1^1(t + 1) \tag{A.7}
\]

\[
\frac{\partial V(A_{t+1}, S_{t+1}^0)}{\partial A_{t+1}} = U_1^0(t + 1) \tag{A.8}
\]

Substituting (A.7) and (A.8) into equation (A.1), we obtain the Euler equation for \( X_t \).

\[
X_t: U_1(t) - \beta(l + r) \left\{ p U_1^1(t + 1) + (1 - p) U_1^0(t + 1) \right\} = 0 \tag{A.9}
\]
To solve for the partial derivatives of the value function in the remaining first order conditions, we use the envelope theorem again. From the envelope theorem:

\[
\frac{\partial V(A_t, S_t)}{\partial S_t} = U_s(t) + \beta \left\{ (1 - \delta - \alpha C_t) \frac{\partial V(A_{t+1}, S_{t+1})}{\partial S_{t+1}} + (1 - \delta)(1 - p) \frac{\partial V(A_{t+1}, S_{t+1}^0)}{\partial S_{t+1}} \right\} \tag{A.10}
\]

To obtain expressions for the partial derivatives of the value function with respect to social capital in each state of the world, substitute first order condition (A.1) into (A.2) and (A.3) to obtain (A.11) and (A.12) respectively.

\[-U_s(t) + U_i(t) \frac{\partial W_e(L_t, S_t)}{\partial L_t} + \beta \gamma (1 - p) \frac{\partial V(A_{t+1}, S_{t+1}^0)}{\partial S_{t+1}} = 0 \tag{A.11}\]

\[-U_s(t) + U_i(t) \frac{\partial W_c(C_t)}{\partial C_t} - \beta \alpha S_t \frac{\partial V(A_{t+1}, S_{t+1}^0)}{\partial S_{t+1}} = 0 \tag{A.12}\]

Substituting (A.11) and (A.12) into (A.10), we obtain:

\[
\frac{\partial V(A_t, S_t)}{\partial S_t} = U_s(t) + \left\{ \frac{(1 - \delta)}{\gamma} \left\{ U_s(t) + U_i(t) \frac{\partial W_e(L_t, S_t)}{\partial L_t} \right\} \right. \\
\left. + \frac{(1 - \delta - \alpha C_t)}{\alpha S_{t+1}} \left\{ U_i(t) \frac{\partial W_c(C_t)}{\partial C_t} - U_s(t) \right\} \right\} \tag{A.13}
\]

Updating (A.13) by one period:

\[
\frac{\partial V(A_{t+1}, S_{t+1})}{\partial S_{t+1}} = U_s(t+1) + \left\{ \frac{(1 - \delta)}{\gamma} \left\{ U_s(t+1) + U_i(t+1) \frac{\partial W_e(L_{t+1}, S_{t+1})}{\partial L_{t+1}} \right\} \right. \\
\left. + \frac{(1 - \delta - \alpha C_{t+1})}{\alpha S_{t+1}} \left\{ U_i(t+1) \frac{\partial W_c(C_{t+1})}{\partial C_{t+1}} - U_s(t+1) \right\} \right\} \tag{A.14}
\]

Evaluating (A.14) at \( S_{t+1}^0 \) and \( S_{t+1}^1 \) respectively, we obtain:

\[
\frac{\partial V(A_{t+1}, S_{t+1}^0)}{\partial S_{t+1}} = U_s^0(t+1) + \left\{ \frac{(1 - \delta)}{\gamma} \left\{ U_s^0(t+1) + U_i^0(t+1) \frac{\partial W_e(L_{t+1}^0, S_{t+1}^0)}{\partial L_{t+1}} \right\} \right. \\
\left. + \frac{(1 - \delta - \alpha C_{t+1}^0)}{\alpha S_{t+1}^0} \left\{ U_i^0(t+1) \frac{\partial W_c(C_{t+1}^0)}{\partial C_{t+1}} - U_s^0(t+1) \right\} \right\} \tag{A.15}
\]

\[
\frac{\partial V(A_{t+1}, S_{t+1}^1)}{\partial S_{t+1}} = U_s^1(t+1) + \left\{ \frac{(1 - \delta)}{\gamma} \left\{ U_s^1(t+1) + U_i^1(t+1) \frac{\partial W_e(L_{t+1}^1, S_{t+1}^1)}{\partial L_{t+1}} \right\} \right. \\
\left. + \frac{(1 - \delta - \alpha C_{t+1}^1)}{\alpha S_{t+1}^1} \left\{ U_i^1(t+1) \frac{\partial W_c(C_{t+1}^1)}{\partial C_{t+1}} - U_s^1(t+1) \right\} \right\} \tag{A.16}
\]
Substitute (A.15) into (3.2) and (A.16) into (A.3) to obtain the Euler equations for time in legitimate income producing activities, $L_i$, and criminal income producing activities, $C_i:

\begin{align*}
L_i: \quad & U_1(t) \frac{\partial W_L(L_i, S_i)}{\partial L_i} - U_2(t) + \beta \gamma(1 - p) \left\{ \frac{(1 - \delta)}{\gamma} - \frac{1 - \delta - \alpha C_{i+1}^0}{\alpha S_{i+1}^0} \right\} U_2^0(t + 1) \\
& + \left\{ \frac{\partial W_L(L_{i+1}, S_{i+1})}{\partial S_{i+1}} + \frac{1 - \delta - \alpha C_{i+1}^0}{\alpha S_{i+1}^0} \right\} \frac{\partial W_C(C_{i+1})}{\partial C_{i+1}} \\
& - \frac{(1 - \delta)}{\gamma} \frac{\partial W_L(L_{i+1}, S_{i+1})}{\partial L_{i+1}} \right\} U_1^0(t + 1) + U_3^0(t + 1) \right\} = 0 \\
C_i: \quad & U_1(t) \frac{\partial W_C(C_i)}{\partial C_i} - U_2(t) - \beta \alpha p S_i \left\{ \frac{(1 - \delta)}{\gamma} - \frac{1 - \delta - \alpha C_{i+1}^1}{\alpha S_{i+1}^1} \right\} U_2^1(t + 1) \\
& + \left\{ \frac{\partial W_L(L_{i+1}, S_{i+1})}{\partial S_{i+1}} + \frac{1 - \delta - \alpha C_{i+1}^1}{\alpha S_{i+1}^1} \right\} \frac{\partial W_C(C_{i+1})}{\partial C_{i+1}} \\
& - \frac{(1 - \delta)}{\gamma} \frac{\partial W_L(L_{i+1}, S_{i+1})}{\partial L_{i+1}} \right\} U_1^1(t + 1) + U_3^1(t + 1) \right\} = 0
\end{align*}

Our final set of Euler equations are:

\begin{align*}
X_i: \quad & U_1(t) - \beta(1 + r) \left\{ p U_1^1(t + 1) + (1 - p) U_1^0(t + 1) \right\} = 0 \\
L_i: \quad & U_1(t) \frac{\partial W_L(L_i, S_i)}{\partial L_i} - U_2(t) + \beta \gamma(1 - p) \left\{ \frac{(1 - \delta)}{\gamma} - \frac{1 - \delta - \alpha C_{i+1}^0}{\alpha S_{i+1}^0} \right\} U_2^0(t + 1) \\
& + \left\{ \frac{\partial W_L(L_{i+1}, S_{i+1})}{\partial S_{i+1}} + \frac{1 - \delta - \alpha C_{i+1}^0}{\alpha S_{i+1}^0} \right\} \frac{\partial W_C(C_{i+1})}{\partial C_{i+1}} \\
& - \frac{(1 - \delta)}{\gamma} \frac{\partial W_L(L_{i+1}, S_{i+1})}{\partial L_{i+1}} \right\} U_1^0(t + 1) + U_3^0(t + 1) \right\} = 0
\end{align*}

39
$$C_i : U_1(t) \frac{\partial W_c(C_i)}{\partial C_i} - U_2(t) - \beta \alpha p S_t \left\{ \left( \frac{1 - \delta}{\gamma} - \left( \frac{1 - \delta - \alpha C_{i+1}}{\alpha S_{i+1}} \right) \right) U_2(i+1) \right. $$

$$+ \left( \frac{\partial W_L(L_{i+1}, S_{i+1})}{\partial S_{i+1}} + \left( \frac{1 - \delta - \alpha C_{i+1}}{\alpha S_{i+1}} \right) \frac{\partial W_c(C_{i+1})}{\partial C_{i+1}} \right) $$

$$- \frac{(1 - \delta)}{\gamma} \frac{\partial W_L(L_{i+1}, S_{i+1})}{\partial L_{i+1}} \right) U_1(i+1) + U_{i+1}(i+1) \right\} = 0 $$
APPENDIX 2
DEFINITION OF VARIABLES

$L_t$  hours worked in labor market per year
$C_t$  hours worked in crime per year
$l_t$  hours of leisure per year
$X_t$  composite consumption good deflated by the CPI
$S_t$  stock of social capital
$W_L$  annual income from labor market
$W_C$  annual income from crime
DAD  dummy = 1 if father present in childhood home
DAI  dummy = 1 if father arrested during childhood
SIBS  number of siblings when growing up
WHITE  dummy = 1 if race is white
SES  dummy = 1 if socioeconomic status is high
GANGLT18  dummy = 1 if individual was in a gang during childhood
MATEBOOK  the number of closest 3 friends during high school picked up by the police
ARCON  proportion of police contacts as a juvenile that result in arrest
M  dummy=1 if begin marriage that year
J  dummy=1 if leave a job and start a new one that year
ED  dummy=1 if level of educate is at least a high school diploma
SCHOOL  dummy=1 if education not completed