# An Intertemporal Model of Rational Criminal Choice*

by

Jenny Williams
University of Adelaide
and

Robin C. Sickles
Rice University

August 20, 2001

## 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. Our model assumes that social capital provides a flow of services associated with a good reputation and social acceptance, and that stigmatism associated with arrest reduces an individual social capital stock. In this way we account for the influence of social norms on the decision to participate in crime. Our model is estimated using panel data from the 1958 Philadelphia Birth Cohort Study. In estimation, we take account of unobserved choices, 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. Specifically, we 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, Method of Simulated Moments

* The authors would like to thank participants of the 8th World Congress of the Econometric Society, The Seventh International Conference on Panel Data and seminar participants at Texas A&M University, Rice University, the Second Annual Texas Econometrics Camp, Australian National University, and The University of Melbourne for their insightful criticisms. Special thanks are extended to Peter Hartley and Herb Emery for their valuable and critical suggestions. The usual caveat applies.

## 1. INTRODUCTION

The basic premise of the economic model of crime is that criminals behave rationally in the sense that they act so as to maximize their economic welfare. This idea can be traced back to Bentham (1970 [1789]) and Beccaria (1963 [1764]), and has been more recently formalized by Becker (1968) and Ehrlich (1973). In this framework, a person breaks the law if the expected utility of doing so exceeds the utility obtained by using his time and other resources in alternative activities. To date, most empirical studies have focused on the opportunity cost of forgone earnings in measuring the costs associated with engaging in crime. However, recent theoretical and empirical research has found that social interactions, working through peer influences, stigma, social norms, and information networks, may also contribute to the cost and benefit calculations of many economic activities.[1]

The role of social interactions would appear to be particularly important in the decision to participate in crime, where stigma associated with arrest may act as a significant deterrent.[2] The magnitude of this effect is likely to differ among individuals according to their peer group. For example, one would imagine that the stigma of arrest would be less of a deterrent to a gang member compared to a university professor. In part, this is because each group has their own code of conduct governing behavior. In the case of street gangs, law-abiding behavior is often neither expected nor valued. Clearly, the extent to which social sanctions can be imposed on an individual who violates the law depends on his attachment to - or investment in - the peer group that respects the law.

This research extends the traditional model of crime to explicitly account for the potential cost of social sanctions in the decision to participate in crime. We use social capital stock to measure an individual's past investment in the law-abiding social group, and assume the cost of social sanctions he faces depends upon the stock of social capital he has accumulated. In this way we account for the influence of social norms on the decision to participate in crime. The intuition behind this model is that attachment to (law-abiding) society through, for example**,** productive employment and marriage, creates a form of state dependence that reduces the likelihood of criminal involvement. In our formulation state dependence arises because the potential costs of engaging in crime are higher for individuals who have good jobs or families compared to those individuals without these attachments.

[1] See for example Akerlof, 1998; Akerlof, 1997; Sampson and Laub, 1993, Case and Katz, 1991.

[2] The importance of the interaction between individuals and their community in forming tastes and determining criminal choices has been studied by Williams and Sickles, 2000; Glaeser, Sacerdote and Scheinkman, 1996;

In addition to offering an explanation for differing criminal propensities across groups in society, our model provides a possible explanation for the age arrest-relationship. Figure 1 shows the age arrest relationship for property arrests for the U.S. in 1999. The shape of this relationship, commonly called the age-crime profile, shows that the arrest rate increases with age up until the late teens, and then declines monotonically. This pattern has been found in studies based on different countries, cities and time periods. In our model, the relationship between age and arrest arises because it takes time to develop institutional relationships and hence accumulate social capital stock. Therefore, crime becomes relatively more expensive and hence less likely for an individual when he is older compared to when he was younger.

From our dynamic structural model of crime, we derive a set of Euler equations describing the optimal allocation of time to crime and legitimate labor market activities, and the optimal level of consumption. The ex-ante optimality conditions depend on choices in each of two possible future states, arrest and escaping arrest. However, only one of these states will be realized and observed in the data. The presence of unobserved choices in the Euler equations pose an omitted regressor problem for estimation, and are potential source of unobserved heterogeneity. We address these issues using simulation techniques and estimate the parameters of our model by Method of Simulated Moments (McFadden, 1989; Pakes and Pollard, 1989; McFadden and Ruud, 1994).

Data from the 1958 Philadelphia Birth Cohort Study (Figlio, Tracy, and Wolfgang, 1991) are used to estimate our dynamic model of criminal choice. These data present a unique opportunity to study the dynamic decision to participate in crime. Typically, data used to study crime at the individual level are generally drawn from high risk populations, such as prison releasees, and consequently suffer from problems arising from selection bias. The data used in this research are sampled from 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.

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. Section 3 provides a description of the 1958 Philadelphia Birth Cohort Study and a discussion of the construction of our index of social

---

Akerlof and Yellen, 1994; and Sah, 1991.

capital stock. In Section 4 we discuss the method for estimating the structural parameters of the model and present the results from estimation. In section 5, we offer some concluding remarks.

## 2. THE MODEL

In the spirit of Ehrlich (1973), we caste our model of criminal choice in a time allocation framework, where time represents the resources devoted to an activity. We extend this traditional static model to a dynamic framework by assuming that an individual's preferences and earnings depend upon his stock of social capital, which is a measure of his investment in the law-abiding group. In this model an individual's stock of social capital provides a flow of services associated with a good reputation and social acceptance within the law-abiding peer group, as well as social networks within this group. Reputation has utility value to the individual, while the networks can be used for occupational advancement and hence raise earnings in the legitimate labor market.

Consider the representative individual who must allocate his time between leisure $\ell_t$, and the two income producing activities of legitimate work, $L_t$, and crime, $C_t$.[3] He must also choose his level of consumption $X_t$. At time *t*, utility is given by:

$$U(X_t, \ell_t, S_t). \tag{2.1}$$

where $S_t$ is the individual's stock of social capital. The utility function, *U(.)* is assumed to be twice differentiable, concave, and increasing in its arguments.

Denoting earnings within a period in terms of the composite good, $X_t$, the individual's intertemporal budget constraint is given by:

$$A_{t+1} = (1+r)(A_t + I_L(L_t, S_t) + I_C(C_t) - X_t) \tag{2.2}$$

where $I_L(L_t, S_t)$ is income from legitimate activity, $I_C(C_t)$ is income from illegitimate activity, and $A_t$ represents the value of accumulated assets. We assume that per period income from legitimate work depends on the number of hours the individual spends working and the level of social capital he has accumulated. While a more general specification would allow both human and social capital stocks to influence earnings directly, including both in the structural model would increase the level of complexity for estimation because we could no longer able to obtain

[3] In earlier work 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 so we have simplified the model by only considering income generating crimes.

closed form solutions for the Euler equations.[4] In order to make the model tractable empirically, we focus on social capital in the theoretical model and control for standard measures of human capital, such as years of schooling and experience, in our empirical model.[5] The pecuniary rewards from income producing crime are assumed to depend only on the amount of resources devoted to this activity, although this assumption is investigated in the empirical modeling of criminal earnings. Income from legitimate and illegitimate activities is assumed to be increasing in their respective arguments.

Investment in social capital is modeled 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. We assume that at the time the individual must choose how to allocate his time, he does not know if he will be arrested for participating in crime. This information is revealed at the end of he period. Thus, in the event of not being arrested (State 0) for crimes committed in time *t*, which occurs with probability *(1-p)*, social capital at *t+1* is given by:

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

where $\delta$ is the depreciation rate of social capital and $\gamma$ transforms resources spent in legitimate activity into social capital. With probability, *p*, the individual will be arrested (State 1) at the beginning of *t+1* for crimes committed in time *t* and a social sanction imposed. This sanction is represented by a loss to the individual's social capital stock. We assume that this loss is an increasing function of the individuals stock of social capital so that, *ceteris paribus*, crime is more costly and therefore less likely for those with a greater stock in society. The loss is also assumed to depend positively on the total amount of time devoted to crime. Thus, in the event of apprehension, social capital at the beginning of *t+1* is given by:

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

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

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:

---

[4] An approach to deal with this is to utilize asymptotic expansions to approximate the value function. In concert with the highly nonlinear Euler equations system and the need to simulate unobserved states of apprehension/escape from apprehension, the additional computational burden of value function approximation is rather daunting. In this paper we concentrate on the social capital accumulation process in developing our theoretical structural dynamic model of crime while incorporating human capital indirectly into the empirical model.

[5] Formally we are assuming that value function is a linear separable function of human capital.

$$V(A_t,S_t)=\max_{X_t,L_t,C_t} U\left(X_t,\ell_t,S_t\right)+\beta\left\{pV\left(A_{t+1},S_{t+1}{}^{1}\right)+(1-p)V\left(A_{t+1},S_{t+1}{}^{0}\right)\right\}$$

Subject to 2.2, 2.3 2.4 and a time constraint $T=\ell_t+L_t+C_t$.[6] By substituting the time constraint in for $\ell_t$, 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[7]:

$$X_t: U_1(t)-\beta(1+r)\left\{pU_1{}^{1}(t+1)+(1-p)U_1{}^{0}(t+1)\right\}=0$$

$$L_t: U_1(t)\frac{\partial I_L(L_t,S_t)}{\partial L_t}-U_2(t)+\beta\gamma(1-p)\left\{\left(\frac{(1-\delta)}{\gamma}-\left(\frac{1-\delta-\alpha C_{t+1}{}^{0}}{\alpha S_{t+1}{}^{0}}\right)\right)U_2{}^{0}(t+1)\right.$$
$$+\left(\frac{\partial I_L\left(L_{t+1}{}^{0},S_{t+1}{}^{0}\right)}{\partial S_{t+1}}+\left(\frac{1-\delta-\alpha C_{t+1}{}^{0}}{\alpha S_{t+1}{}^{0}}\right)\frac{\partial I_C(C_{t+1}{}^{0})}{\partial C_{t+1}}\right.$$
$$\left.\left.-\frac{(1-\delta)}{\gamma}\frac{\partial I_L\left(L_{t+1}{}^{0},S_{t+1}{}^{0}\right)}{\partial L_{t+1}}\right)U_1{}^{0}(t+1)+U_3^0(t+1)\right\}=0$$

$$C_t: U_1(t)\frac{\partial I_C(C_t)}{\partial C_t}-U_2(t)-\beta\alpha pS_t\left\{\left(\frac{(1-\delta)}{\gamma}-\left(\frac{1-\delta-\alpha C_{t+1}{}^{1}}{\alpha S_{t+1}{}^{1}}\right)\right)U_2{}^{1}(t+1)\right.$$
$$+\left(\frac{\partial I_L\left(L_{t+1}{}^{1},S_{t+1}{}^{1}\right)}{\partial S_{t+1}}+\left(\frac{1-\delta-\alpha C_{t+1}{}^{1}}{\alpha S_{t+1}{}^{1}}\right)\frac{\partial I_C(C_{t+1}{}^{1})}{\partial C_{t+1}}\right.$$
$$\left.\left.-\frac{(1-\delta)}{\gamma}\frac{\partial I_L\left(L_{t+1}{}^{1},S_{t+1}{}^{1}\right)}{\partial L_{t+1}}\right)U_1{}^{1}(t+1)+U_3^1(t+1)\right\}=0$$

where $U_i{}^{j}(t+1)$ is the marginal utility of argument i (i=1, 2,3) in state j (j=0,1) at time t+1 and $C_{t+1}{}^{j}$, $L_{t+1}{}^{j}$ represent choices in t+1 in state j.

The usual condition for optimality in consumption is given by the Euler equation for the aggregate consumption good, with 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 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

[6] An alternative formulation of the dynamic programming problem would include arrest status as a state variable. Using Theorem 4.2 of Stokey, Lucas and Prescott (1989), Hartley (1996) shows that the solution to this problem will also solve the problem as formulated in the text.

three Euler equations and two earnings equations give a closed form solution for the optimal allocation of resources.

## 3. DATA

We use individual level data drawn from the 1958 Philadelphia Birth Cohort Study to estimate the model developed in Section 2. Since these data have not had widespread use in economics literature, we begin with a description of the 1958 Philadelphia Birth Cohort Study and then discuss the sample used in the empirical part of the paper.

### 3.1. The 1958 Philadelphia Birth Cohort Study.

The purpose of the 1958 Philadelphia Birth Cohort Study was to collect data on a birth cohort with a special focus on their delinquent and criminal activities. The cohort is composed of subjects who were born in 1958 and who resided in the city of Philadelphia at least from their tenth until their 18th birthday. The 27,160 members of this universe were identified using the Philadelphia school census, the U.S. Bureau of Census, and public and parochial school records. Once the members of this cohort were identified, data collection occurred in 2 phases.

The first phase of data collection involved assembling the complete official criminal history of the cohort. This was accomplished during the years 1979 and 1984 and provides coverage of the criminal careers, as recorded by the police, and juvenile and adult courts, for the entire 27,160 members of the cohort. The information for juveniles was obtained from the Philadelphia police, Juvenile Aid Division (JAD). Information about adult arrests was obtained from the Philadelphia Police Department, the Common and Municipal Courts, and the FBI, ensuring offenses both within and outside the boundaries of Philadelphia are included in the data set.

The second stage of the Study entailed a retrospective follow-up survey for a sample from the 27,160 members of the cohort. Figlio and his co-investigators employed a stratified sampling scheme to ensure that they captured the most relevant background and juvenile offense characteristics of the cohort and yield a sample size sufficient for analysis. The population was stratified five ways: by gender, race, socio-economic status, offense history (0, 1, 2-4, 5 or more offenses), and juvenile "status" offenses, which are offense categories only applicable to individuals less than 18 years of age. The follow-up survey took place during 1988, with 576 men and 201 women interviewed. Most respondents resided within the Philadelphia SMSA or within a 100 mile radius of the urban area. However, to insure that out-migration of cohort

---

[7] The derivation of the Euler equations is given in Appendix 1.

members from Philadelphia would not have any significant effect, sample members were traced and if possible contacted, throughout the United States. Figlio (1994) reports that comparisons among strata indicate no apparent biases due to non-response. Areas of inquiry covered by the survey include personal history of delinquency and criminal acts; gang membership; work and education histories; composition of current and childhood households; marital history; parental employment and educational histories; parental contact with the law; and personal and social demographic characteristics.

**3.2 The Sample**

By combining the information from the retrospective survey and official arrest records, we have both self-reported information on criminal involvement and actual arrests, complete work histories, educational attainment, and a range of socio-economic and background characteristics for the sample captured in the retrospective survey. We consider only males from the follow-up survey, and only those for whom we can construct all key variables required for our analysis. Observations for which the respondent was a full time student were dropped, so that leisure and work are the only alternatives to crime. Our final data set contains observations on 423 men over the ages of 19-24 corresponding to the period 1977 to 1982. A definition of variables and summary statistics are presented in Table 1.[8]

The choice variables from the structural model are annual hours in the labor market, annual hours in income producing crime, and (real) annual consumption. Income producing crimes are defined to be robbery, burglary, theft, forgery and counterfeiting, fraud, and buying, receiving or possessing stolen property. The annual number of hours worked in the legitimate labor market is a standard variable, constructed from the question “How many hours per week did you usually work on this job?”, which was asked of each job recorded in the respondent’s work history. Construction of the annual number of hours spent in crime is based on an aggregated measure of crimes committed each year. The Sellin-Wolfgang seriousness scoring scale is used to aggregate self-reported and official arrest information on crimes committed by the respondent each year. The seriousness score is then converted to hours per year by matching the seriousness score to survey data recording hours spent in crime reported by Freeman (1992). Details on the construction of these variables can be found in Appendix 2.

In addition to the empirical counterparts to the variables in the structural model, Table 1 contains sample statistics for background characteristics that are used to construct the index of

---

[8] Since our data are from a stratified random sample, the statistics in Table 1 are calculated using weights to reflect

social capital stock. These variables and the method used to construct the index are discussed later in this section.

## 3.3 Measuring Social Capital

### 3.3.1 Current Social Capital Stock

We assume that gross investment in social capital in the sample period is generated by engaging in activities that develop institutional relationships such as attachment to the workforce and marriage. While providing detailed information on employment history, the 1958 Philadelphia Birth Cohort Study data do not provide information on the level of involvement individuals have in their community. However, the Study does contain information about what Laub and Sampson (1993) and Sampson and Laub (1993) would consider turning points, such as marriage and beginning a new job. While much of the criminology literature has emphasized stability and continuity, Sampson and Laub argue that transitions are also important in understanding an individual's criminality, as these events may modify long term patterns of behavior. For example, getting married forms social capital through a process of the reciprocal investment between husbands and wives. This investment creates an interdependent system of obligation and restraint and increases an individual's bonds to society. Also, young males tend to have high job turnover rates. If leaving a job and starting a new one *in the same period* is attributable to upward employment mobility, then a new job increases attachment to the legitimate sector when the employer's act of investing in the individual is reciprocated. Additionally, a better job increases an individual's system of networks. Each of these life events tend to increase an individual's ties to the legitimate community and thus increase his social capital.

In our empirical specification we follow the approach of Sampson and Laub, allowing the life-course turning points of getting married (GETMARRIED) and leaving and beginning a new job in the same period (CHANGEJOB) to build stock in society. We account for stability of labor market attachment in our measure of social capital through annual hours spent in the legitimate labor market (L). Social capital also depends on the state of the world, which is learnt at the end of each period. In the event of not being arrested (State 0) for crimes committed in time $t$ ($C_t$), social capital at $t+1$ is given by:

$$S^0_{t+1} = (1-\delta)S_t + \gamma_1 L_t + \gamma_2 GETMARRIED_t + \gamma_3 CHANGEJOB_t \qquad (3.1)$$

---

the population from which the sample are drawn.

where $\delta$ is the depreciation rate of social capital and the $\gamma$'s transform resources spent in legitimate activity into social capital.

Unlike legitimate income earning activities, criminal activity is not sanctioned by society. We model this by assuming that arrests result in a loss to the individual's social capital stock. As described in Section 2 the loss is assumed to depend positively on the resources devoted to crime and the level of social capital stock the individual has accumulated. Thus, in the event of apprehension, (State 1) social capital at *t+1* is given by:

$$S_{t+1}^{1} = (1-\delta)S_t - \alpha C_t S_t \tag{3.2}$$

where $\alpha$ represents the technology that transforms resources spent in crime into a social sanction. In order to estimate the weights $(\delta, \alpha, \gamma_1, \gamma_2, \gamma_3)$ in the capital accumulation process, we substitute equations 3.1. and 3.2 in for $S_{t+1}^{0}$ and $S_{t+1}^{1}$ respectively in the Euler equations from section 2. Once an initial level of social capital stock has been specified, these parameters can be estimated along with the other parameters of interest in the model.

### 3.3.2 Initial Value of Social Capital Stock.

We assume that the initial period level of social capital stock possessed by an individual is inherited from his family, since cohort members are eighteen at the beginning of our analysis. Our choice of variables determining inherited social capital stock is based on empirical evidence from the literature, and the availability of these measures in our data. Becker (1991) notes that the fortunes of children are linked to their parents through endowments, such as family reputation and connections, knowledge, skills, and goals provided by the family environment. According to Coleman (1988), who developed the idea of social capital, and the empirical literature on delinquency surveyed by Visher and Roth (1986), the institution of the family is central to the transmission of social norms to children and children's involvement in crime. Coleman notes that the creation of family bonds as a means of parents' instilling norms in their children depends not just upon the presence and willingness of the parents, but also on the relationship the children may have with competing norms and cultures, such as gang culture. Therefore, we look to variables that reflect the strength of bonds between parents and children, and the social capital accumulated by the parents as inputs to our index of family specific social capital stock.

Given our data, we account for each of these influences with the following variables: the socio-economic status of the individual's family during his childhood, race, whether the father was present in the childhood home, the number of siblings, whether the father was arrested during the individual's childhood, whether high school friends were in trouble with the police, gang membership during childhood, and the number of juvenile arrest relative to police contacts.

Obtaining a set of weights for aggregating variables such as presence of father, and gang affiliation during childhood raises the classic index number problem. Maasoumi (1986, 1993) shows that the (normalized) first principal component from the data on attributes can be used as weights to summarize these attributes into a composite index. In our application, we follow this approach.[9]

Table 2 lists the variables used in the construction of the initial level of social capital and the corresponding (normalized) weights associated with the first principal component. The signs of the weights indicate that coming from a white two-parent household with a high socioeconomic status, having a father with no arrests (during the individual's childhood), not being involved in a gang, and having friends who were not in trouble with the police contributes to the social capital stock an individual accumulates during childhood. The negative weight on the number of siblings indicates that the social capital stock a child inherits from his family is decreased by the presence of siblings. This is consistent with Coleman's (1988) finding that siblings dilute parental attention, which negatively effects the transmission of social capital from parents to child. Youths' involvement in criminal activity as measured by the ration of juvenile arrests to police contacts also has a negative weight, indicating that juvenile arrests reduce the social capital stock accumulated during childhood. Inherited social capital is constructed as the weighted sum of these variables.

Our index of inherited social capital stock should provide a measure of the degree to which an individual is "at risk" of criminal involvement and arrest in the sample period. Specifically, we would expect a negative relationship between social capital stock and criminal involvement, with those individuals with a smaller stock spending more time in crime and being more likely to be arrested than individuals who inherited a larger stock. We investigate whether this expectation is satisfied by diving the sample into quartiles based on the initial level of social capital stock and comparing the first and fourth quartiles in terms of two measures of criminal involvement: arrests and time in crime. This comparison is contained in Table 3, shows that individuals from the first quartile of inherited social capital stock account for a much larger

[9] These weights are sample specific. As an alternative, Maasoumi (1986,1989) suggests that the weights given to the attributes may be the researcher's subjective weights. Factor analysis is an alternative means to obtain weights. However, Kim and Mueller (1978) note that principal components has an advantage over factor analysis if the objective is a simple summary of information contained in the raw data, since the method of principal components does not require the strong assumptions underlying factor analysis.

proportion of annual arrests for the sample than men from the fourth quartile, and this difference becomes more pronounced over time. Table 3 also reports the average time in crime for both the high and low risk groups, and shows that the high risk group do spent a much larger amount of time in crime relative to the low risk group. Although not reported, a t-test for the equality of means (allowing for unequal variances) between the low and high risk groups finds a significant difference for each year. This confirms that the initial level of social capital stock is a good predicator of propensity for criminal involvement in adulthood.

## 4. EMPIRICAL MODEL

The Euler equations derived from the structural model of crime in section 2 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 observed in the data. The unobserved choices cause an omitted regressor problem in estimation and are a potential source of unobserved heterogeneity. While it is possible to estimate the three Euler equations and two income equations simultaneously, the absence of unobserved choices in the earnings equations makes a sequential estimation process computationally convenient. However, because the parameters governing social capital accumulation are estimated from the Euler equations, and are then used to construct the social capital stock that appears in the earnings equations, the estimation algorithm iterates between earnings and Euler equation estimation.

In terms of describing our estimation strategy, we begin with describing estimation of the parameters in the earnings equations, which draws on standard techniques. The following section describes the method for estimating the parameters of the utility function and social capital accumulation function form the Euler equations, which is based on the Method of Simulated Moments (McFadden and Ruud, 1994; McFadden, 1989; Pakes and Pollard, 1989).

### 4.1 The Earnings Equations

#### 4.1.1 Estimation Methodology for the Earnings Equations

The model presented in section 2 focuses on the role of social capital in decisions regarding participation in crime and work. This leads to a specification for criminal earnings that depends on resources the individual allocates to that activity, and legitimate labor market earnings that depends on both hours spent working and social capital stock. However, in addition to the large empirical literature on human capital, empirical research by Freeman (1996) suggests that the returns to legitimate opportunities relative to the returns to crime also depend on human capital. Further, he finds that human capital affects relative income through raising returns to work. To reflect this in our empirical model, we adopt a more general specification that includes human capital as a determinant of legitimate earnings. We also explore whether criminal human capital (and legitimate human capital) raises the returns to time in crime.

Income in each sector is defined as the product of the number of hours spent in that sector and that sectors hourly wage:

$$I_L = w_L(H_t, S_t, Z_t).L_t$$

$$I_C = w_C(K_t, Z_t).C_t$$

where $w_L$ and $w_C$ are the hourly wage in the legitimate labor market and criminal labor markets respectively. $L_t$ 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 $t$, $H_t$ is legitimate human capital, represented by years of schooling and labor market experience, $K_t$ is criminal human capital, and $Z_t$ represents a vector of socioeconomic and demographic characteristics including marital status, number of children and race. We measure criminal human capital stock using the number of juvenile arrests as a proxy for experience, and proxy criminal networking with a variable indicating whether the respondent's father was arrested in the respondent's youth and a variable measuring the respondent's number of siblings.

The wage equations are intended to provide us with information allowing us to make statements regarding the determinants of wages for the entire sample of men. However, the decision to participate in each sector is endogenous, and only a sub-sample of the population is engaged in either or both of the income producing activities. If the decision to work in legitimate or illegitimate activities depends on unobservable characteristics that also influence wages, 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 (Heckman 1974, 1979).

### 5.1.2 Earnings Equation Results

The estimates for the Heckman sample selection corrected wage equations for criminal and legitimate activities are given presented in Table 4. Hourly wages in the legitimate labor market are constructed by linear interpolation between the reported pay the individual received when they started and left each job in their employment history. If earnings were reported as weekly (yearly), the hourly wage is calculated as the weekly (yearly) wage divided by the usual hours worked per week (usual hours worked per week multiplies by 50 weeks). Annual criminal income is defined as the total value of stolen goods from arrests and self reported offenses. The hourly wage for property crime is then calculated as the annual income divided by the number of hours spent in crime that year. A full description of the construction of this variable is given in Appendix 2**.**

The parameter estimates for wages in legitimate labor market activities are consistent with the standard predictions of human capital theory. Legitimate wages are a increasing in years of schooling, and are a concave function of labor market experience. In addition to the human capital theory of earnings, we find evidence that institutional knowledge and networks, as captured by our measure of social capital stock, has a positive and significant impact on earnings. These results suggest that both human capital and social capital are significant determinants of wages.

In contrast to labor market wages, we are unable to explain criminal wages with criminal human capital variables. Nor are we able to explain criminal wages with the legitimate human capital measures. The joint hypothesis that criminal (legitimate) human capital and the socioeconomic and demographic variables are significant in explaining criminal wages is rejected at conventional levels of significance, with a p-values for the Wald test statistic of 0.59 (0.57). This may reflect problems with measuring criminal income, hours, or criminal human capital. Alternatively, the finding may reflect that criminal earnings are not related to either legitimate or criminal human capital. We note that while not significant in determining wages, two out of three measures of criminal human capital (number of juvenile arrests and father was arrested in respondent's youth) are significant in explaining participation in crime, as is martial status, and social capital, with participation less likely at higher levels of social capital stock. While we cannot rule out measurement issues as the reason for being unable to explain criminal wages, we note that Freeman (1996) finds that human capital affects relative income through raising returns to legitimate work rather than through criminal income.[10] Also Gottfredson and Hirschi (1990) concluded that for the vast majority of income generating crimes such as theft and burglary, there is no evidence of criminal human capital accumulation. From the combined evidence, it may be reasonable to infer that criminal returns are not a function of criminal human capital.

As we are unable to explain criminal wages with human capital, criminal capital, or socioeconomic and demographic variables, we adopt the assumption used in the theoretical model that criminal income depends on time spent in crime only. Accordingly, we estimate a criminal income function as follows:

---

[10] Specifically, he regressed the share of income from illegal sources on human capital measures and found that the

$$W_C(C_t) = \mu_0 + \mu_1 C_t + \mu_2 C_t^2 + \varepsilon_{Ct}$$

Since time in crime is a choice variable potentially correlated with the error term in the earnings equation, and is truncated below by zero, we correct for the potential for sample selection bias by adopting the methodology suggested in Vella (1998). This approach is similar to the parametric two-step approach of Heckman (1974, 1979). In the first step, we assume normality of the error term in the latent variable reduced form equation for hours worked, leading to a Tobit specification. 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 $\sum_{k=1}^{K} \alpha^k \hat{v}_i^k$, where the $\hat{v}_i$'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 illegitimate income producing activities) for the subsample who participate provides consistent OLS estimates of parameters in the criminal earnings equation. Provided $K$ is treated as known, these estimates are $\sqrt{n}$ consistent, and the second step covariance matrix can be computed.

The results from estimating the sample selection corrected criminal earnings function are presented in Table 5. They show that annual income from crime is 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.

Given there are increasing returns to time in crime we would 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. Among criminals who do work, an average of one and one-half hours per week is spent 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 non-deviant behavior in the preference structure. We investigate this hypothesis in the next section by estimating the Euler equations associated with the optimal allocation of time to criminal and legitimate activities, and consumption.

### 5.2 The Euler Equations

---

coefficients on all human capital variables were negative and significant.

### 5.2.1 Estimation Methodology for the Euler Equations

Let $S_{it}$ denote the value of the state variable, social capital stock, for the *ith* individual in period *t*, $x_{it}$ denote the vector of choice variables entering the *ith* individual's Euler equations in period *t*, and let $x_{it+1}$ be those variables dated *t+1*. Our sample is a panel of *T=5* periods of observations on a random sample of *N=423* individuals. We assume that the earnings in the legal sector and crime are parameterized as above and that utility has the following transcendental logarithmic form:

$$U\left(X_{it},\ell_{it},S_{it}\right)=\alpha_1 \ln X_{it}+\alpha_2 \ln \ell_{it}+\alpha_3 \ln S_{it}+\frac{1}{2}\left\{\beta_{11}\left(\ln X_{it}\right)^2+\beta_{22}\left(\ln \ell_{it}\right)^2+\beta_{33}\left(\ln S_{it}\right)^2\right\}$$
$$+\beta_{12}\ln X_{it}\ln \ell_{it}+\beta_{13}\ln X_{it}\ln S_{it}+\beta_{23}\ln \ell_{it}\ln S_{it}.$$

Each of these Euler equations can be written in the form of $f_j\left(x_{it},S_{it},\theta_0\right)-g_j\left(x_{it+1},S_{it+1},\theta_0\right)$, $j=1,2,3$, where $f(.)$ is the observed response function which depends on current period variables, and $g(.)$ is the expected response function, which depends on next period's variables, and $\theta_0$ is the *px1* vector of parameters to be estimated.[11] 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, $\mathrm{u}_{\mathrm{it}}$, are idiosyncratic so that at any time, the expectation of this disturbance term over *individuals* is zero. The *ith* individual's system of equations is represented as:

$$f\left(x_{it},S_{it},\theta_0\right)-g\left(x_{it+1},S_{it+1},\theta_0\right)=u_{it}\,.$$

Conditional moment restrictions take the form, $E\left[u_{it}\middle| z_{it}\right]=0$, where $z_{it}$ are observed data. The population orthogonality conditions can be written as:

$$E_N\left[\frac{1}{T}\sum_{t=1}^{T}\left(f\left(x_{it},S_{it},\theta_0\right)-g\left(x_{it+1},S_{it+1},\theta_0\right)\right)\otimes z_{it}\right]=E_N\left[M(x_i,S_i,z_i,\theta_0)\right]=0\,.$$

For all admissible $\theta$, the sample average of $M(x_i,S_i,z_i,\theta_0)$ is assumed to converge to its population mean

$$\lim_{N\to\infty}\frac{1}{N}\sum_{i=1}^{N}\left[M(x_i,S_i,z_i,\theta_0)\right]=E_N\left[M(x_i,S_i,z_i,\theta_0)\right].$$

The GMM estimator $\theta_{mm}$ of the unknown parameter vector $\theta_0$ is defined as the

[11] We assume a real rate of interest of 3%, and a time rate of preference of 0.95 The representative individual's per period optimal choice of time allocations ($L_t$, $C_t$) and consumption ($X_t$) are parameterized by $\theta_0=\left(\alpha_1,\alpha_2,\alpha_3,\beta_{11},\beta_{22},\beta_{33},\beta_{12},\beta_{13},\beta_{23},\alpha,\delta,\gamma_1,\gamma_2,\gamma_3\right)$.

$$\arg\min_{\theta}\left[\frac{1}{N}\sum_{i=1}^{N}\left[M(x_i,S_i,z_i,\theta)\right]\right]' W_N\left[\frac{1}{N}\sum_{i=1}^{N}\left[M(x_i,S_i,z_i,\theta)\right]\right]$$

where $W_N$ is a symmetric positive definite weighting matrix which satisfies:

$$\lim_{N\to\infty} W_N \overset{as}{\longrightarrow} W_0 .$$

The choice of weighting matrix that produces the efficient or optimal GMM estimator is estimator is $W_0 = \Omega^{-1}$, where $\Omega$ is consistently estimated by $\Omega_N = \frac{1}{N}\sum_{i=1}^{N}\left[(u_i \otimes z_i)(u_i \otimes z_i)'\right]$

In practice, implementing GMM as an estimator for the parameters in our system of Euler equations is hampered by the fact that while agents' decisions are based on ex-ante expectations of the future, 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 modification of the conventional Method of Moments estimator as the basis for the Method of Simulated Moments.[12]

To illustrate our use of MSM, 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, $\Pi(x|S_{t+1})$. Recall that $S_{t+1}$ 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 for a given set of parameters governing social capital accumulation. 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

[12] 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 $W_0$ and $x_{it}$, is zero, and (ii) the simulation residual process is uniformly stochastically bounded and equicontinuous in $\theta$.

$$\frac{1}{T}\sum_{t=1}^{T}\left[\frac{1}{S}\sum_{s=1}^{S}\Big(f\big(x_{it},S_{it},\theta_0\big)-g\big(x_{it+1}{}^{s},S_{it+1},\theta_0\big)\Big)\otimes z_{it}\right]=\mu(x_i,S_i,z_i,\theta_0) \quad \text{where}$$

$$\lim_{N\to\infty} E_N\left[\frac{1}{N}\sum_{i=1}^{N}\left[\mu\,(x_i,S_i,z_i,\theta_0)\right]\right]=E_N\left[M(x_i,S_i,z_i,\theta_0)\right]$$

Note that although we motivate the estimation methodology as a way of dealing with uncertainty about future states, the use of simulation techniques conditioned on individual characteristics may also be viewed as a partial control for unobserved individual heterogeneity in those states.

## 5.4 Euler Equation Results

The system of Euler equations derived in Section 2 is estimated using MSM on 423 individuals over the period 1977 to 1981. The coefficient on the logarithm of social capital $(\alpha_3)$ is normalized at unity, leaving eight coefficients form the translog utility function and five parameters from the social capital accumulation process to be estimated. With three equations and eleven instruments, the number of overidentifying restrictions is twenty. The Hansen test statistic for overidentifying restrictions is 6.65, compared to a $\chi^2_{0.95,20}$ =10.85 so the null hypothesis that the system is overidentified is not rejected. The MSM estimates of the preference parameters are presented in the top half of Table 6, and the parameters governing the accumulation of social capital stock in the bottom half of this table. Six of the eight coefficients form the translog utility function, and three from the social capital accumulation process are statistically significant. It is noteworthy that all three terms in the translog utility function involving social capital are 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 ($ln\, X_t\, ln\, \ell_t$), consumption and social capital ($ln\, X_t\, ln\, S_t$), and leisure and social capital ($ln\, \ell_t\, ln\, S_t$) all are all negative. Our estimates imply that consumption and leisure are complements in utility. This is consistent with the work of Hotz, Kydland and Sedlacek (1988), Sickles and Taubman (1997), and Sickles and Yazbeck (1998)[13]. The relationships between consumption and social capital, and leisure and

[13] Other studies, however, find evidence that these goods are substitutes (Altonji ,1986; Ghez and Becker, (1975) ; Thurow, (1969)).

social capital, are also complementary. Moreover, these interaction terms are statistically significant.

Turning to the parameters governing social capital accumulation, we estimate a statistically significant depreciation rate on social capital stock $(\delta)$ of 3%. The sign on the point estimates of time in the labor market $(\gamma_1)$, getting married $(\gamma_2)$, and changing jobs $(\gamma_3)$ are all positive, indicating that they each contribute to social capital stock accumulation, although only $\gamma_1$ and $\gamma_3$ are statistically significant. The coefficient on the social penalty for arrest $(\alpha)$ implies a loss of 1% of social capital stock evaluated at the sample average of time in crime. Evaluated at the mean annual hours spent in crime amongst the criminally active, the social sanction is about 5% of social capital stock.

Returning to the preference parameters, Table 7 shows that the estimated marginal utilities of consumption, leisure, and social capital are positive for all time periods[14]. The value of an incremental increase in the consumption good drops from aged 19 to twenty, and rises from the age of 20 for our sample of young men. The marginal utility of leisure declines steeply between the ages of nineteen and twenty, continues to decline between the ages of 20 and 21,a dn tehn increases over the ages of 21-23. Based on these estimates, the average marginal rate of substitution of is 0.056, implying an hourly wage of $4.18 over the sample period[15]. The marginal rate of substitution of consumption for leisure 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 older individuals place a higher value on leisure time.

Table 7 also shows that the marginal utility of social capital increases over the lifecycle 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, 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

[14] These are obtained by evaluating at sample averaged (across individuals) data.
[15] This number is calculated by multiplying the marginal rate of substitution by the CPI, where the CPI is averaged over 1977 to 1981.

investment. This is a necessary condition for adjacent complementarity[16]. Since past labor market participation raises social capital stock, which raises future labor supply, we also find reinforcement in decision making.

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. The results are presented in Table 8. These results indicate that utility is most sensitive to changes in leisure and least responsive to changes in social capital. 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. In contrast, they become less responsive to changes in leisure. This finding is further support of growing state dependence in preferences.

In our dynamic mode, social capital stock accumulation increases the expected cost of engaging in crime, 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 2 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 the age-crime profile.

Our model performs well at explaining the decline in participation in crime for the average of our sample. However, the more important question may be how well it explains the behavior of those most at risk of criminality. Our index of social capital allows us to investigate this issue, since 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. To address this question, we partition the sample into quartiles on the basis of initial period social capital stock and compare the temporal pattern in the marginal utility of social capital for the first and fourth quartiles, the individuals most and least at risk individuals. Figure 3 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

[16] See Ryder and Heal ( 1973 ) and Becker and Murphy (1988).

social capital for individuals from the first quartile (high risk group) displays a markedly different temporal pattern, as shown in Figure 4. 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.

Recall from Table 3 that, 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. These men appear to be embedded in a criminal peer group by the age of 18, when our study begins, and may consider social capital to hinder their advancement in the criminal peer group. This interpretation is consistent with a negative marginal utility associated with social capital. While state dependence in crime appears to diminish over the ages of 19 to 21, as indicated by the 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. The implication of this is 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.

## 7. CONCLUSION

In this paper we integrate the intertemporal choice and economics of crime literature to develop a dynamic model of criminal choice that focuses on the role of stigma as a deterrent to crime. Current period decisions affect future outcomes by a process of social capital accumulation. Our model assumes that social capital provides a flow of services associated with a good reputation and social acceptance, and that stigmatism associated with arrest reduces an individual social capital stock. In this way we account for the influence of social norms on the decision to participate in crime.

Using data from the 1958 Philadelphia Birth Cohort Study, we find significant empirical support for the dynamic model of crime. The selectivity corrected earnings equation estimates for labor market activities indicate that legal wages are increasing in both human and social capital. Application of a method of simulated moments estimator to the 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, the model provides an explanation of the empirical relationship between aggregate arrests and age.

We also investigate the performance of the model in explaining the behavior of individuals who differ in their degree of being at risk of becoming criminals. 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.

This last finding is of particular interest as it raises the issue of preventative policy for youth. While the traditional economic model of crime provides a basis for formulating deterrence policy, it is silent on preventative policy. The debate over whether prison pays indicates that justifying the costs of incarceration at current levels is questionable and that crime prevention policies for crime prone groups are likely to be more attractive on a cost benefit basis (Freeman, 1996). In order to contribute to the policy discussion on preventative policy, however, economics must explore dynamic models of crime that provide a mechanism for understanding the way in which preventative policy impacts individuals' potential criminal behavior. Our results suggest that further development of social capital models of crime to include human capital accumulation may prove to be a fruitful means for exploring this issue.

## REFERENCES


Akerlof, G. A. and Yellen, "Gang Behavior, Law Enforcement and Community Value," in Aaron, H. J., T. E. Mann, and T. Taylor, (eds.) *Values and Public Policy*, (Washington D.C.: Brookings Institute, 1994), 173-209.

Akerlof, G. A., "Social Distance and Social Decisions," *Econometrica* 65 (1997), 1005-1027.

__________, "Men Without Children," *The Economic Journal* 108 (1998), 287-309

Altonji, J. G., "Intertemporal Substitution in Labor Supply: Evidence From Micro Data," *Journal of Political Economy* 94 (1986), S176-S213.

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

Becker, G, "Crime and Punishment: An Economic Approach," *Journal of Political Economy*, LXXVI (1968), 169-217.

______, *A Treatise on the Family* (Cambridge, MA: Harvard University Press 1991).

Becker, Gary S. and Kevin M. Murphy, "A Theory of Rational Addiction," *Journal of Political Economy 96* (1988), 675-699.

Bentham, J., *An Introduction to the Principles of Morals and Legislation* (London: Athlone Press, 1970 [1789]).

Case, A. and L. Katz, "The Company You Keep: The Effects of Family and Neighborhood on Disadvantaged Youths," Working Paper, National Bureau of Economic Research, Cambridge, MA, (1991).

Coleman, J. S., "Social Capital in the Creation of Human Capital," *American Journal of Sociology* 94 (1988), S95-S120.

Ehrlich, I., "Participation in Illegitimate Activities: A Theoretical and Empirical Investigation," *Journal of Political Economy* LXXXI (1973), 521-65.

Figlio, R., "Self-Reported and Officially defined Offenses in the 1958 Philadelphia Birth Cohort," NATO ASI, Series D, Behavioural and Social Sciences 76 (1994), 267-280.

Figlio, M., P. E. Tracy, and M. E. Wolfgang, *Delinquency in A Birth Cohort II: Philadelphia 1958-1986:* Computer File. Second Release. Philadelphia, PA: Sellin Center for Studies in Criminology and Criminal Law and National Analysts, Division of Booz-Allen and Hamilton, Inc.: Producers, 1990. Ann Arbor, MI: ICPSR 1991.

Freeman, R. B., "Employment and Earnings of Disadvantaged Young Men in a Labor Short Economy," in *The Urban Underclass*, edited by C. Jencks and P.E. Peterson (Brookings Institute, Washington, D.C. 1991)

Freeman, R. B., "Crime and the Economic Status of Disadvantaged Young Men," in *Urban Labor Markets and Job Opportunities*, edited by G.E. Peterson and W. Vroman (Urban Institute, Washington, D.C. 1992)

______, "Why Do So Many Young American Men Commit Crimes and What Might We Do About It?," *Journal of Economic Perspectives* 10 (1996), 25-42.

Ghez, G., and G. Becker, "*The Allocation of Time and Goods over the Life Cycle*," (New York, NY. Columbia University Press (for N.B.E.R.), 1975).

Glaeser, Edward L., Bruce Sacerdote, and José A. Scheinkman, "Crime and Social Interactions," *The Quarterly Review of Economics* (1996), 507-548.

Gottfredson, M. R. and T. Hirschi, *A General Theory of Crime* (Stanford, CA. Stanford University Press, 1990).

Hansen, L. P., "Large Sample Properties of Generalized Method of Moments Estimators," *Econometrica* 50 (1982), 1029-1054.

Hartley, P. R., "Numerical Approximation of a Value Function in the Presence of Inequality Constraints: An Application to the Demand for Credit Cards," Journal of Economic Dynamics and Control, Vol. 20, 1996, 63-92.

Heckman, J., “Shadow Price, Market Wages and Labor Supply,” *Econometrica* 42 (1974), 679-674.

________, “Sample Selection Bias as a Specification Error,” *Economerica* 47 (1979), 153-161.

Hotz, J. V., F. E. Kydland, and G. L. Sedlacek, “Intertemporal Preferences and Labor Supply,” *Econometrica* 56 (1988), 335-360.

Kim, J. and C. W. Mueller *Factor Analysis: Statistical Methods and Practical Issues* (Beverly Hills, CA: Sage Publications, 1978)

Laub, J. H., and R. J.Sampson, “Turning Points in the Life Course: Why Change Matters to the Study of Crime,” *Criminology* 31, (1993), 301-325.

Maasoumi, E., “The Measurement and Decomposition of Multi-Dimensional Inequality,” *Econometrica* 54 (1986), 991-997.

__________, “A Compendium to Information Theory in Economics and Econometrics,” *Econometric Reviews* 12 (1993), 137-181.

McFadden, D. and P. Ruud, “Estimation by Simulation,” *Review of Economics and Statistics* 76 (1994), 591-608.

McFadden, D., “A Method of Simulated Moments for Estimation of Discrete Response Models without Numerical Integration,” *Econometrica* 57 (1989), 995-1026.

Pakes, A. and D., Pollard “Simulation and the Asymptotics of Optimization Estimates” *Econometrica* 57 (1989), 1027-1058.

Ryder, Harle E. Jr. and Geoffrey M. Heal, “Optimum Growth with Intertemporally Dependent Preferences,” *Review of Economic Studies* 40 (1973), 1-33.

Sah, R. K, “Social Osmosis and Patterns of Crime,” *Journal of Political Economy* 99 (1991), 1272-1295.

Sampson, R. J. and J. H. Laub, “Crime and Deviance in the Life Course,” *Annual Review of Sociology* 18 (1993), 63-84.

Sellin, T. and M. E. Wolfgang, *The Measurement of Delinquency* (New York: JohnWiley and Sons, 1964).

Sickles, R. C. and P. Taubman, "Mortality and Morbidity Among Adults and the Elderly," Chapter 16 of the *Handbook of Population and Family Economics*, edited by Mark R. Rosenzweig and Oded Stark, Amsterdam: North-Holland (1997), 559-643.

Sickles, R. C. and A. Yazbeck, “On the Dynamics of Demand for Leisure and the Production of Health,” *Journal of Business and Economic Statistics* 16 (1998), 187-197.

Thurow, L. C., “The Optimum Lifetime Distribution of Consumption Expenditures,” *American Economic Review* 59 (1969), 324-330.

Visher, C. A. and J. A. Roth, “Participation in Criminal Careers,” in *Criminal Careers and ‘Career Criminals’ Vol. I*, A. Blumstein, et al. (eds.) (Washington, DC: National Academy Press, 1986), 211-291.

Vella, F., 1998. "Estimating Models with Sample Selection Bias: A Survey." Journal of Human Resources 33(1) (1998),127-172.

Williams, J. and R.C. Sickles, “An Analysis of the Crime as Work Model: Evidence from the 1958 Philadelphia Birth Cohort Study,” Journal of Human Resources, forthcoming (2000).

## Table 1

| DEFINITION | MEAN | STANDARD DEVIATION |
|---|---|---|
| ***Model Variables*** | | |
| hours worked ($L$) | 1498.04 | 934.61 |
| hours in income generating crime (C) | 65.55 | 180.40 |
| leisure hours ($\ell$) | 4260.42 | 916.79 |
| real consumption per year (X) | 119.23 | 84.65 |
| social capital index (S) | 102.81 | 20.84 |
| real annual labor income ($W_L$) | 100.69 | 91.83 |
| real annual crime income($W_C$) | 3.08 | 17.04 |
| ***Determinants of Social Capital & Earnings*** | | |
| Binary equal to 1 if socio-economic status of family during childhood up is high | 0.57 | 0.50 |
| Binary equal to 1 if race is white | 0.56 | 0.50 |
| Binary equal to 1 if father present in childhood home | 0.86 | 0.35 |
| Binary equal to 1 if father not arrested during childhood | 0.92 | 0.28 |
| Binary equal to 1 if not a gang member during childhood | 0.82 | 0.39 |
| Number of siblings (divided by ten) | 0.32 | 0.23 |
| Proportion of best 3 friends not picked up by the police during high school | 0.63 | 0.44 |
| Number of police contacts as a juvenile | 0.72 | 0.45 |
| Proportion of contacts as a juvenile that result in an arrest | 0.16 | 0.32 |
| Binary equal to 1 if begin a marriage that year | 0.05 | 0.21 |
| Binary equal to 1 if end and then begin a job that year | 0.10 | 0.30 |
| Binary equal to 1 if arrested that year | 0.05 | 0.22 |
| Binary equal to 1 if arrested for a property offense that year | 0.03 | 0.17 |
| Binary equal to 1 if married | 0.13 | 0.33 |
| Binary equal to 1 if in a common law marriage | 0.08 | 0.28 |
| number of children | 1.00 | 1.13 |
| Years of schooling | 12.59 | 1.98 |
| Years of Labor Market experience | 1.52 | 1.68 |
| Indicator for Juvenile Arrests | 0.14 | 0.31 |

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

| **Variable** | **Weight** |
| --- | --- |
| father present in childhood home | 0.15 |
| father not arrested during childhood | 0.07 |
| number of siblings | -0.04 |
| race is white | 0.25 |
| socioeconomic-economic status is high | 0.29 |
| not a gang member | 0.28 |
| proportion of best 3 friends from high school not picked up by the police | 0.18 |
| proportion of police contacts as a juvenile that result in arrest | -0.18 |

**Table 3**
***Arrests and Time in Crime: First and Fourth Quartiles***

| **Year** | **First Quartile** | | **Fourth Quartile** | |
| --- | --- | --- | --- | --- |
| | proportion of total arrests | time in crime | proportion of total arrests | time in crime |
| 78 | 0.33 | 192 | 0.08 | 36 |
| 79 | 0.46 | 170 | 0.04 | 30 |
| 80 | 0.45 | 138 | 0.10 | 30 |
| 81 | 0.40 | 138 | 0.10 | 24 |
| 82 | 0.57 | 134 | 0.09 | 27 |

## Table 4

### *Selection Corrected Equations for Hourly Wages in Work and Crime*

| | work | | crime | | crime | |
|---|---|---|---|---|---|---|
| **log hourly wage** | **parameter** | **t-value** | **parameter** | **t-value** | **parameter** | **t-value** |
| years of schooling | 0.026 | 3.008 | -0.086 | -1.228 | -0.079 | -1.069 |
| experience | 0.069 | 2.574 | | | 0.240 | 1.288 |
| experience squared | -0.009 | -2.267 | | | -0.051 | -1.465 |
| father arrested during respondent's childhood | | | -0.157 | -0.524 | | |
| number of juvenile arrests | | | -0.153 | -0.419 | | |
| number of siblings | | | -0.072 | -1.577 | | |
| social capital | 0.001 | 2.138 | 0.001 | 0.100 | 0.002 | 0.218 |
| race is white | 0.057 | 2.185 | 0.058 | 0.186 | 0.104 | 0.322 |
| indicator for married | 0.025 | 0.865 | 0.288 | 0.887 | 0.219 | 0.668 |
| indicator fro in a common law marriage | 0.088 | 2.477 | -0.281 | -0.825 | -0.268 | -0.734 |
| year | -0.045 | -4.446 | -0.042 | -0.515 | -0.042 | -0.485 |
| constant | 0.338 | 0.448 | 1.308 | 0.204 | 0.626 | 0.093 |
| p-value of Wald test for joint significance of regressors | | 0.000 | | 0.592 | | 0.565 |
| **participation** | | | | | | |
| years of schooling | 0.153 | 4.530 | -0.034 | -1.265 | -0.034 | -1.271 |
| experience | 1.020 | 12.614 | -0.127 | -2.007 | -0.128 | -2.073 |
| experience squared | -0.116 | -7.378 | 0.005 | 0.417 | 0.005 | 0.458 |
| social capital | 0.008 | 2.631 | -0.017 | -7.319 | -0.017 | -7.299 |
| race is white | 0.257 | 2.605 | 0.442 | 5.225 | 0.442 | 5.223 |
| indicator for married | 0.543 | 3.148 | -0.002 | -0.021 | -0.004 | -0.034 |
| indicator fro in a common law marriage | 0.175 | 1.303 | 0.545 | 5.065 | 0.546 | 5.063 |
| number of children | 0.032 | 0.997 | -0.040 | -1.417 | -0.041 | -1.420 |
| moved out of parents home | -0.027 | -0.161 | | | 0.031 | 0.223 |
| father was arrested | -0.375 | -2.944 | 0.248 | 2.235 | 0.247 | 2.218 |
| number of juvenile arrests | -0.270 | -1.975 | 0.373 | 3.655 | 0.373 | 3.631 |
| number of siblings | -0.035 | -1.676 | -0.009 | -0.544 | -0.009 | -0.553 |
| year | -0.150 | -4.200 | -0.017 | -0.566 | -0.016 | -0.535 |
| constant | 9.418 | 3.335 | 2.533 | 1.079 | 2.473 | 1.045 |
| p-value of Lagrange Multiplier test for independent equations | | 0.963 | | 0.931 | | 0.941 |

## Table 5

### *Selection Corrected Criminal Annual Earnings Equation*

| **criminal earnings** | **parameter** | **t-value** |
|---|---|---|
| hours in crime | 0.009 | 0.560 |
| hours in crime squared | 0.000 | 3.190 |
| resid | -0.014 | -0.642 |
| resid2 | 0.000 | 0.000 |
| resid3 | 0.000 | 0.000 |
| constant | 7.718 | 4.050 |
| pvalue of F test for joint significance of correction terms | | 0.740 |
| **hours in crime** | | |
| years of schooling | -14.546 | -1.303 |
| experience | -48.416 | -1.878 |
| experience squared | 2.450 | 0.506 |
| social capital | -7.648 | -7.896 |
| race is white | 128.467 | 3.685 |
| indicator for married | 31.115 | 0.677 |
| indicator fro in a common law marriage | 174.480 | 4.076 |
| number of children | -24.820 | -2.109 |
| moved out of parents home | 1.273 | 0.023 |
| father was arrested | 169.382 | 3.852 |
| number of juvenile arrests | 122.220 | 2.822 |
| number of siblings | -0.566 | -0.082 |
| year | -13.947 | -1.115 |
| constant | 1648.632 | 1.679 |

## Table 6

### *Estimates of Structural Parameters from Euler Equation Estimation*

| | **co-eff** | **t-value** |
|---|---|---|
| **translog utility function parameters** | | |
| $lnX_t$ | 0.2258 | 2.09 |
| $\ln \ell_t$ | 0.2060 | 0.47 |
| $(lnX_t)^2$ | 0.0028 | 2.61 |
| $(\ln \ell_t)^2$ | 0.1069 | 2.09 |
| $(lnS_t)^2$ | 0.1908 | 2.85 |
| $lnX_t \ln \ell_t$ | -0.0179 | -1.46 |
| $lnX_t\ lnS_t$ | -0.0160 | -6.31 |
| $lnS_t \ln \ell_t$ | -0.2141 | -6.61 |
| **social capital accumulation parameters** | | |
| $\delta$ | 0.0299 | 2.23 |
| $\gamma 1$ | 0.0003 | 0.64 |
| $\gamma 2$ | 4.0800 | 1.37 |
| $\gamma 3$ | 15.1400 | 1.76 |
| $\alpha$ | 0.0002 | 0.67 |

**Table 7**
***Marginal Utility of Consumption, Leisure and Social Capital****

| Age | Consumption | Leisure | Social Capital |
|---|---|---|---|
| *19* | 0.000144 | 0.0000084 | 0.000024 |
| *20* | 0.000130 | 0.0000074 | 0.000079 |
| *21* | 0.000131 | 0.0000072 | 0.000118 |
| *22* | 0.000134 | 0.0000074 | 0.000129 |
| *23* | 0.000136 | 0.0000076 | 0.000140 |

**Table 8**
***Responsiveness of Utility to a 1% Increase in Consumption, Leisure and Social Capital****

| Age | Consumption | Leisure | Social Capital |
|---|---|---|---|
| *19* | 0.00380 | 0.00972 | 0.00061 |
| *20* | 0.00428 | 0.00804 | 0.00198 |
| *21* | 0.00448 | 0.00761 | 0.00294 |
| *22* | 0.00456 | 0.00778 | 0.00318 |
| *23* | 0.00464 | 0.00783 | 0.00342 |

FIGURE 1


* Age specific Crime rate=100,000*(number of arrests of persons in the age group/population in the age group)
Source: Adapted from Snyder H. Juvenile Arrests 1999. Washington, DC: Office of Juvenile Justice and Delinquency Prevention, 2000.

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

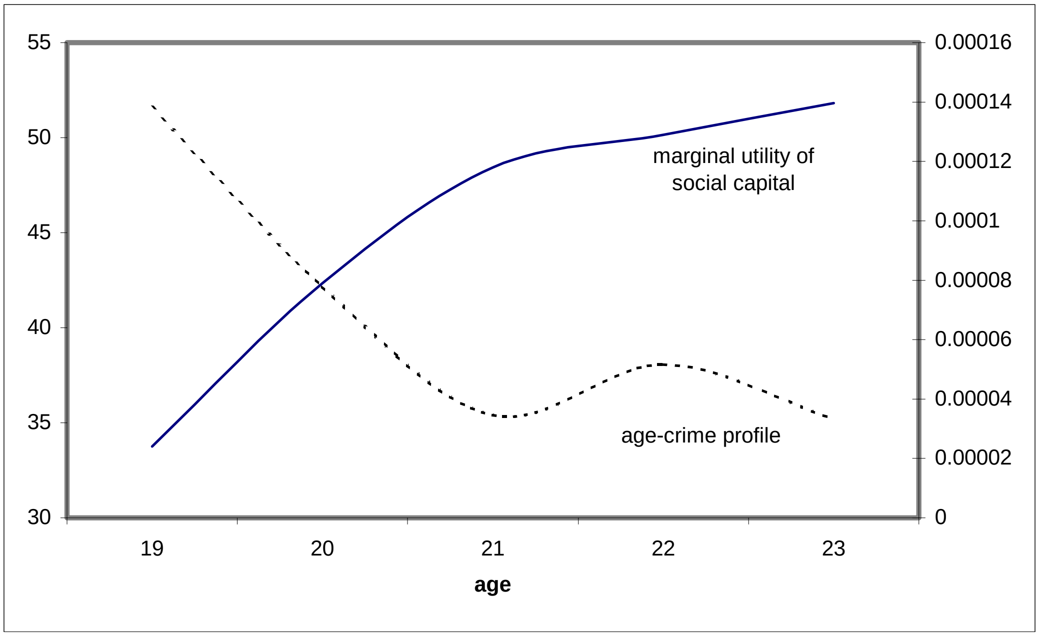



**Figure 3.**
***The Marginal Utility of Social Capital for the Fourth Quartile***

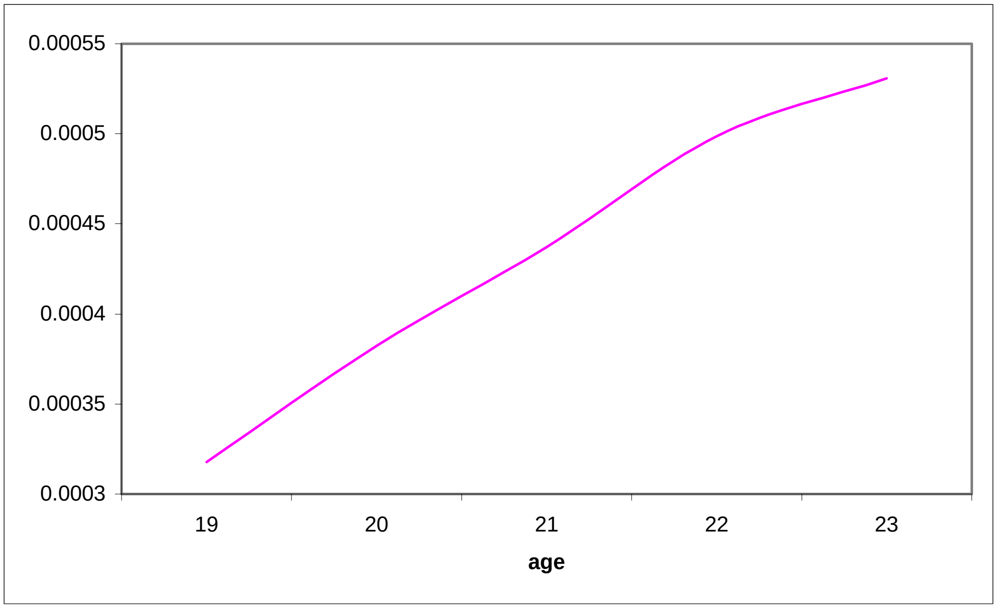
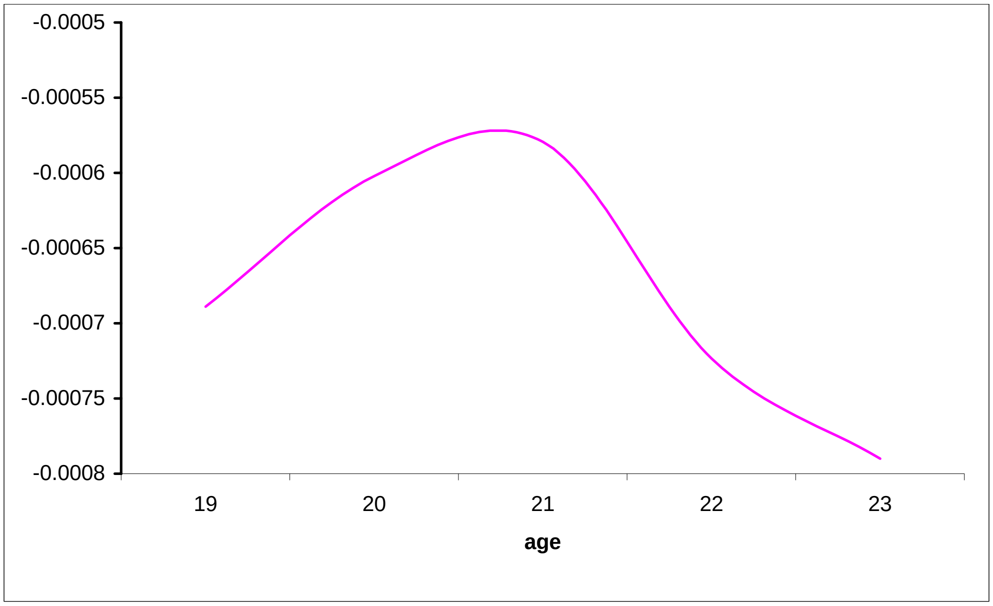


**Figure 4.**
***The Marginal Utility of Social Capital for the First Quartile***



**Appendix 1**

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

$$\frac{\partial V\left(A_t, S_t\right)}{\partial X_t} = U_1(t) - \beta(1+r)\left\{ p\frac{\partial V\left(A_{t+1}, {S_{t+1}}^1\right)}{\partial A_{t+1}} + (1-p)\frac{\partial V\left(A_{t+1}, {S_{t+1}}^0\right)}{\partial A_{t+1}}\right\} = 0 \qquad \text{(A.1)}$$

$$\begin{aligned}\frac{\partial V\left(A_t, S_t\right)}{\partial L_t} &= -U_2(t) + \beta\gamma(1-p)\frac{\partial V\left(A_{t+1}, {S_{t+1}}^0\right)}{\partial S_{t+1}} \\ &+ \beta(1+r)\frac{\partial W_L(L_t, S_t)}{\partial L_t}\left\{ p\frac{\partial V\left(A_{t+1}, {S_{t+1}}^1\right)}{\partial A_{t+1}} + (1-p)\frac{\partial V\left(A_{t+1}, {S_{t+1}}^0\right)}{\partial A_{t+1}}\right\} = 0\end{aligned} \qquad \text{(A.2)}$$

$$\begin{aligned}\frac{\partial V(A_t, S_t)}{\partial C_t^I} &= -U_2(t) + \beta(1+r)\frac{\partial W_C(C_t^I)}{\partial C_t^I}\left\{\frac{p\partial V(A_{t+1}, {S_{t+1}}^1)}{\partial A_{t+1}} + (1-p)\frac{\partial V(A_{t+1}, {S_{t+1}}^0)}{\partial A_{t+1}}\right\} \\ &- \alpha\beta S_t p\frac{\partial V(A_{t+1}, {S_{t+1}}^1)}{\partial S_{t+1}} = 0\end{aligned} \qquad \text{(A.3)}$$

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:

$$\frac{\partial V(A_t, S_t)}{\partial A_t} = \beta(1+r)\left\{ p\frac{\partial V(A_{t+1}, {S_{t+1}}^1)}{\partial A_{t+1}} + (1-p)\frac{\partial V(A_{t+1}, {S_{t+1}}^0)}{\partial A_{t+1}}\right\} \qquad \text{(A.4)}$$

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

$$\frac{\partial V(A_t, S_t)}{\partial A_t} = U_1(t) \qquad \text{(A.5)}$$

Updating (A.5) one period:

$$\frac{\partial V(A_{t+1}, S_{t+1})}{\partial A_{t+1}} = U_1(t+1) \qquad \text{(A.6)}$$

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

$$\frac{\partial V(A_{t+1}, {S_{t+1}}^1)}{\partial A_{t+1}} = U_1^1(t+1) \qquad \text{(A.7)}$$

$$\frac{\partial V(A_{t+1}, {S_{t+1}}^0)}{\partial A_{t+1}} = U_1^0(t+1) \qquad \text{(A.8)}$$

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

$$X_t : U_1(t) - \beta(1+r)\left\{ p{U_1}^1(t+1) + (1-p){U_1}^0(t+1)\right\} = 0 \qquad \text{(A.9)}$$

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:

$$\frac{\partial V(A_t,S_t)}{\partial S_t} = U_3(t) + U_1(t)\frac{\partial W_L(L_t,S_t)}{\partial S_t} + \beta\left\{(1-\delta-\alpha C_t)p\frac{\partial V(A_{t+1},S_{t+1}{}^1)}{\partial S_{t+1}} + (1-\delta)(1-p)\frac{\partial V(A_{t+1},S_{t+1}{}^0)}{\partial S_{t+1}}\right\} \quad \text{(A.10)}$$

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.

$$-U_2(t) + U_1(t)\frac{\partial W_L(L_t,S_t)}{\partial L_t} + \beta\gamma(1-p)\frac{\partial V(A_{t+1},S_{t+1}{}^0)}{\partial S_{t+1}} = 0 \quad \text{(A.11)}$$

$$-U_2(t) + U_1(t)\frac{\partial W_C(C_t)}{\partial C_t} - \beta\alpha S_t\, p\frac{\partial V(A_{t+1},S_{t+1}{}^1)}{\partial S_{t+1}} = 0 \quad \text{(A.12)}$$

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

$$\frac{\partial V(A_t,S_t)}{\partial S_t} = U_3(t) + U_1(t)\frac{\partial W_L(L_t,S_t)}{\partial S_t} + \frac{(1-\delta)}{\gamma}\left\{U_2(t) + U_1(t)\frac{\partial W_L(L_t,S_t)}{\partial L_t}\right\} + \frac{(1-\delta-\alpha C_t)}{\alpha S_t}\left\{U_1(t)\frac{\partial W_C(C_t)}{\partial C_t} - U_2(t)\right\} \quad \text{(A.13)}$$

Updating (A.13) by one period:

$$\frac{\partial V(A_{t+1},S_{t+1})}{\partial S_{t+1}} = U_3(t+1) + U_1(t+1)\frac{\partial W_L(L_{t+1},S_{t+1})}{\partial S_{t+1}} + \frac{(1-\delta)}{\gamma}\left\{U_2(t+1) + U_1(t+1)\frac{\partial W_L(L_{t+1},S_{t+1})}{\partial L_{t+1}}\right\} + \frac{(1-\delta-\alpha C_{t+1})}{\alpha S_{t+1}}\left\{U_1(t+1)\frac{\partial W_C(C_{t+1})}{\partial C_{t+1}} - U_2(t+1)\right\} \quad \text{(A.14)}$$

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

$$\frac{\partial V(A_{t+1},S_{t+1}{}^0)}{\partial S_{t+1}} = U_3{}^0(t+1) + U_1{}^0(t+1)\frac{\partial W_L(L_{t+1}{}^0,S_{t+1}{}^0)}{\partial S_{t+1}} + \frac{(1-\delta)}{\gamma}\left\{U_2{}^0(t+1) + U_1{}^0(t+1)\frac{\partial W_L(L_{t+1}{}^0,S_{t+1}{}^0)}{\partial L_{t+1}}\right\} + \frac{(1-\delta-\alpha C_{t+1}{}^0)}{\alpha S_{t+1}{}^0}\left\{U_1{}^0(t+1)\frac{\partial W_C(C_{t+1}{}^0)}{\partial C_{t+1}} - U_2{}^0(t+1)\right\} \quad \text{(A.15)}$$

$$\frac{\partial V(A_{t+1},S_{t+1}{}^1)}{\partial S_{t+1}} = U_3{}^1(t+1) + U_1{}^1(t+1)\frac{\partial W_L(L_{t+1}{}^1,S_{t+1}{}^1)}{\partial S_{t+1}} + \frac{(1-\delta)}{\gamma}\left\{U_2{}^1(t+1) + U_1{}^1(t+1)\frac{\partial W_L(L_{t+1}{}^1,S_{t+1}{}^1)}{\partial L_{t+1}}\right\} + \frac{(1-\delta-\alpha C_{t+1}{}^1)}{\alpha S_{t+1}{}^1}\left\{U_1{}^1(t+1)\frac{\partial W_C(C_{t+1}{}^1)}{\partial C_{t+1}} - U_2{}^1(t+1)\right\} \quad \text{(A.16)}$$

Substitute (A.15) into (3.2) and (A.16) into (A.3) to obtain the Euler equations for time in legitimate income producing activities, $L_t$, and criminal income producing activities, $C_t$:

$$L_t : U_1(t)\frac{\partial W_L(L_t, S_t)}{\partial L_t} - U_2(t) + \beta\gamma(1-p)\left\{\left(\frac{(1-\delta)}{\gamma} - \left(\frac{1-\delta-\alpha C_{t+1}{}^0}{\alpha S_{t+1}{}^0}\right)\right)U_2{}^0(t+1)\right.$$

$$+\left(\frac{\partial W_L(L_{t+1}{}^0, S_{t+1}{}^0)}{\partial S_{t+1}} + \left(\frac{1-\delta-\alpha C_{t+1}{}^0}{\alpha S_{t+1}{}^0}\right)\frac{\partial W_C(C_{t+1}{}^0)}{\partial C_{t+1}}\right.$$

$$\left.\left.-\frac{(1-\delta)}{\gamma}\frac{\partial W_L(L_{t+1}{}^0, S_{t+1}{}^0)}{\partial L_{t+1}}\right)U_1{}^0(t+1) + U_3^0(t+1)\right\} = 0$$

$$C_t : U_1(t)\frac{\partial W_C(C_t)}{\partial C_t} - U_2(t) - \beta\alpha p S_t\left\{\left(\frac{(1-\delta)}{\gamma} - \left(\frac{1-\delta-\alpha C_{t+1}{}^1}{\alpha S_{t+1}{}^1}\right)\right)U_2{}^1(t+1)\right.$$

$$+\left(\frac{\partial W_L(L_{t+1}{}^1, S_{t+1}{}^1)}{\partial S_{t+1}} + \left(\frac{1-\delta-\alpha C_{t+1}{}^1}{\alpha S_{t+1}{}^1}\right)\frac{\partial W_C(C_{t+1}{}^1)}{\partial C_{t+1}}\right.$$

$$\left.\left.-\frac{(1-\delta)}{\gamma}\frac{\partial W_L(L_{t+1}{}^1, S_{t+1}{}^1)}{\partial L_{t+1}}\right)U_1{}^1(t+1) + U_3^1(t+1)\right\} = 0$$

Our final set of Euler equations are:

$$X_t : U_1(t) - \beta(1+r)\left\{pU_1{}^1(t+1) + (1-p)U_1{}^0(t+1)\right\} = 0$$

$$L_t : U_1(t)\frac{\partial W_L(L_t, S_t)}{\partial L_t} - U_2(t) + \beta\gamma(1-p)\left\{\left(\frac{(1-\delta)}{\gamma} - \left(\frac{1-\delta-\alpha C_{t+1}{}^0}{\alpha S_{t+1}{}^0}\right)\right)U_2{}^0(t+1)\right.$$

$$+\left(\frac{\partial W_L(L_{t+1}{}^0, S_{t+1}{}^0)}{\partial S_{t+1}} + \left(\frac{1-\delta-\alpha C_{t+1}{}^0}{\alpha S_{t+1}{}^0}\right)\frac{\partial W_C(C_{t+1}{}^0)}{\partial C_{t+1}}\right.$$

$$\left.\left.-\frac{(1-\delta)}{\gamma}\frac{\partial W_L(L_{t+1}{}^0, S_{t+1}{}^0)}{\partial L_{t+1}}\right)U_1{}^0(t+1) + U_3^0(t+1)\right\} = 0$$

$$C_t : U_1(t)\frac{\partial W_C(C_t)}{\partial C_t} - U_2(t) - \beta\alpha p S_t\left\{\left(\frac{(1-\delta)}{\gamma} - \left(\frac{1-\delta-\alpha C_{t+1}{}^1}{\alpha S_{t+1}{}^1}\right)\right)U_2{}^1(t+1)\right.$$

$$+\left(\frac{\partial W_L(L_{t+1}{}^1, S_{t+1}{}^1)}{\partial S_{t+1}} + \left(\frac{1-\delta-\alpha C_{t+1}{}^1}{\alpha S_{t+1}{}^1}\right)\frac{\partial W_C(C_{t+1}{}^1)}{\partial C_{t+1}}\right.$$

$$\left.\left.-\frac{(1-\delta)}{\gamma}\frac{\partial W_L(L_{t+1}{}^1, S_{t+1}{}^1)}{\partial L_{t+1}}\right)U_1{}^1(t+1) + U_3^1(t+1)\right\} = 0$$

## Appendix 2: Measuring Time in Crime and Income from Crime

### Construction of Number of Crimes

Since the self reported information on crime is reported by age categories, and not individual years, the construction of time in crime is broken into two steps. In the first step, we create the total number of crimes for each person for each year. The second step is to aggregate the different types of crimes, which is done by scoring each crime on the basis of the Sellin-Wolfgang seriousness scoring index.

In the first stage, we create annual observations on the *number* of crimes for each member of the sample from self reported crimes for the 19-24 age category. We create annual observations from the self report data by 'distributing' the self-reported crimes across the 6 years spanned by the age category 19 to 24. This requires assumptions about both participation and frequency of offending during this time period. Figlio's (1994) analysis of the self-report for males in the follow-up survey found that the percentage of individuals committing offenses was constant between the 19-24 and 25+ age groups when all offense types were considered. On this basis, we make the assumption that there is a constant participation in crime during the years 1977-1982. If the participation rate is constant, then the total number of arrests/period for this cohort should reflect the intensity (or frequency) with which participants commit crimes. The self-report data on the 423 men are grouped to obtain offenses corresponding to different income producing crimes. Official arrest records for the 13,160 males in the cohort are similarly classified. For each crime category, we create the weights to distribute the self reported crimes to individual years using the proportion of arrests for the cohort during the period 1977-1982 that occurred in each of the individual years. The weights are then used to distribute the self reported crimes across the six year period.

In order to convert the quantity of crimes into *time* in crime requires a basis for comparison and aggregation across the different crime types. Sellin and Wolfgang (1964) propose a seriousness scoring scale that uses the effects of the crimes rather than specific legal labels to index the gravity of criminal behavior. We use the index of severity as a metric for comparison and aggregation of different crimes. To score a crime, detailed information is required (see Appendix 3, on the seriousness scoring system). This data was collected from the rap sheets on arrests and seriousness scores calculated. However, the information is unknown for crimes for which no arrests take place. In this case, seriousness scores must be generated. We do this by taking random draws from the distribution of seriousness scores for arrests in the corresponding crime category. Annual observations on crime are obtained by aggregating seriousness scores for each individual within a year.

Next, we use information from the 1989 Boston Youth Survey, reported in Freeman (1992) to benchmark our severity index to hours spent in crime. Freeman reports that 52% of individuals who reported criminal activity spent no more than 3 hours per week in crime, 26% spent between four and eight hours per week in crime, while 22% spent more than eight hours per week in crime. Freeman also reports that individuals who engage in crime at least once a week earn, on average, $5400 per year, and that, on the basis of reported hours spent on the most recent crime, their hourly wage was $9.75. Benchmarking our seriousness score to Freeman's data on time in crime for the individuals from the Boston Youth Survey who reported criminal activity provides us with an average of about 66 hours in income generating crimes annually.

**Construction of Income from Crimes**

Total annual income from self-reported crimes and actual arrests is constructed in the same step as the index of severity of crime. For actual arrests, we use the value of stolen property as our measure of income from crime. For the self reported crimes the value of stolen property - in addition to is the seriousness score for the crime - is unknown. In order to generate observations on income from self reported crime, when we take random draws from the seriousness scores for arrests in the same category as the self-reported crime, we also draw the value of stolen property. Total income from crime per year is then the sum of income from crimes for which the individual was arrested and the simulated income for self reported crimes. For the criminally active, the annual average income form crime (in nominal terms) is about $1,212. This is somewhat less than the average annual income of $1,607 (in 1980 dollars) for active offenders reported by Freeman (1991) using data from a survey of adolescents in three cities. Our estimated income is also less than the annual income for active offenders of roughly $2,000 (in 1980 dollars) Freeman (1992) estimates for Boston youth sample. We note however, that we not include income from selling drugs, which is likely to explain why we obtain a lower estimate of income.

## APPENDIX 3: THE SELLIN-WOLFGANG SERIOUSNESS SCORING SCALE

In order that we may analyze crime, and not have to worry about aggregating different offenses, the Sellin Wolfgang seriousness scoring scale is used. The appeal of this approach is that it uses the effects of the crimes rather than the specific legal labels attached to them to index the severity or gravity of criminal behavior. The seriousness scores of offense gravity consist of three parts. The first part is constructed utilizing events which involve violations of the criminal law that inflict bodily harm on one or more victims and/or cause property loss by theft or damage or destruction. In order to score criminal events for this part of the scale, the following rap-sheet information included in the adult offense file was used:

1 The number of victims who, during the event receive minor bodily injuries or are treated and discharged, hospitalized, or killed.

2. The number of victims of acts of forcible sexual intercourse.

3. The presence of physical or verbal intimidation or intimidation by a dangerous weapon.

4. The number of premises forcibly entered.

5. The number of motor vehicles stolen and whether the vehicle was or was not recovered.

The following table lists the seriousness scoring components and the weights devised by Wolfgang and Sellin used for the first part of the seriousness score. The score for an event is computed as follows. The weights are multiplied by the number of victims who were affected, multiplied by the various scores, and summed.

**Table A3.1**
***Seriousness Scoring Components and Weights***

| **Component** | **Weight** |
|---|---|
| **1. Physical injury** | |
| a. minor harm | 1.5 |
| b. treated and discharged | 8.5 |
| c. hospitalization | 12.0 |
| d. fatal | 35.7 |
| **2. Forcible sex acts** | 26.0 |
| **3. Intimidation** | |
| a. verbal or physical | 4.9 |
| b. by weapon | 5.6 |
| **4. Premises forcibly entered** | 1.5 |
| **5. Motor Vehicles stolen** | |
| a. recovered | 4.5 |
| b. unrecovered | 8.1 |

The adult offense file also has a second and third part to the seriousness score, which focuses on the seriousness of crimes that have no 'victims', nor involve theft or property damage. The final seriousness score used in the analysis is the aggregate of the three parts.