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Why are criminals less educated than non-criminals?

Evidence from a cohort of young Australian twins

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Abstract in English

Many studies find a strong negative association between crime and education. This raises the question whether crime reduces investment in human capital or whether education reduces criminal activity. This paper investigates this question by using fixed effect estimation on data of Australian twins. We find that early arrests (before the age of 18) have a strong effect on human capital accumulation. In addition, we find that education decreases crime. However, controlling for early arrests and early behaviour problems reduces the estimated effect of human capital on crime to less than on third of the previously estimated association. From this, we conclude that the strong association between human capital and crime is mainly driven by the effect of early criminal behaviour on educational attainment. The strong detrimental effects of early criminal behaviour become also transparent if we consider the estimated effects of early arrests on three measures of crime. We find large effects of early criminal behaviour on participation in crime later on. This suggests that programs that succeed in preventing early criminal behaviour might yield high social and private returns.

Key words: Education, crime, causal effects

JEL code: I2, K42

Abstract in Dutch

In veel studies is een negatieve samenhang gevonden tussen onderwijs en criminaliteit. Dit roept de vraag op of criminaliteit leidt tot het volgen van minder onderwijs of dat onderwijs leidt tot minder criminaliteit. Deze studie onderzoekt deze vraag door gebruik te maken van gegevens van Australische tweelingen en door rekening te houden met genetische en sociaal-economische factoren die gedeeld worden door tweelingen. Arrestaties op jonge leeftijd (vóór het 18e jaar) hebben een sterk effect op het bereikte onderwijsniveau. Bovendien vinden we dat onderwijs leidt tot minder criminaliteit. Echter, het effect van onderwijs op criminaliteit daalt met meer dan tweederde als rekening gehouden wordt met arrestaties op jonge leeftijd en antisociale gedragsstoornissen. Dit betekent dat de sterke samenhang tussen onderwijs en criminaliteit grotendeels bepaald wordt door het effect van arrestaties op jonge leeftijd op onderwijs. Ook vinden we dat vroeg crimineel gedrag een sterk effect heeft op crimineel gedrag op latere leeftijd. Dit suggereert dat programma's die erin slagen crimineel gedrag op jonge leeftijd terug te dringen, hoge private en sociale opbrengsten kunnen genereren.

Steekwoorden: Onderwijs, criminaliteit, causale effecten

Een uitgebreide Nederlandse samenvatting is beschikbaar via www.cpb.nl.

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Summary

This paper aims at disentangling the strong association between human capital and crime by investigating whether crime reduces investment in human capital or whether education reduces criminal activity. Heretofore, we exploit two aspects of the Australian survey data on education and crime we use. First, as the data are obtained from twins, we are able to control for many unobserved characteristics affecting both criminal behaviour and the schooling decisions. Second, as criminal behaviour is measured over different periods of time – prior to and after senior high school completion – we can address the causality between crime and education as well. As early criminal behaviour may affect human capital formation, and human capital may influence criminal behaviour in later stages of life, we follow a two step analysis.

First, we address the effects of early criminal behaviour on educational attainment. The estimates suggest that early criminal behaviour is detrimental to investment in human capital. Within pairs of twins we find that early arrests (before the age of 18) reduce educational attainment with .7 to .9 years and lower the probability of completing senior high school with 20 to 23 percentage points. In addition, the timing of the early arrest matters, arrests at age 13, 14 or 15 are most detrimental for educational attainment. These estimates are found after controlling for conduct disorder and early school performance.

Second, we focus on the effect of human capital on crime. As early criminal activity might be an important confounder, we control for early arrests. The estimates suggest that human capital has a negative effect on crime. Completing senior high school reduces the probability of incarceration with 2 to 3 percentage points. We find similar but statistically insignificant effects on the probability of being arrested since the age of 18 and on the number of arrests. The size of these estimates might be downward biased because of measurement error in schooling. IV-estimates using a second independent measure of schooling suggest that the effect of human capital might be larger. Lochner and Moretti (2004) report IV-estimates of the effect of high school completion on imprisonment of 8 percentage points for blacks and 0.9 for whites.

When combining these findings, it seems that the causality between human capital and crime runs in both directions. Still, the impact of early criminal behaviour on human capital formation dominates the impact of human capital formation on future crime behaviour. Controlling for early arrests and early behaviour problems reduces the estimated effect of human capital on crime to less than a quarter of the previously estimated association. From this, we conclude that early criminal behaviour explains most of the association between human capital and crime.

The strong detrimental effects of early criminal behaviour become also transparent if we consider the estimated effects of early arrests on all three measures of crime. Early arrests increase the probability of incarceration with 20 percentage points and the probability of being arrested since the age of 18 with 10 percentage points. These effects are much larger than the estimated effects of human capital. For instance, the estimated effect of being arrested before

the age of 18 on incarceration is almost ten times higher than the estimated effect of completing high school.

In line with previous studies (Lochner and Moretti, 2004, Machin and Vujic, 2006) our findings suggest that policies that succeed in raising investment in human capital might reduce crime. However, the (direct) returns to policies that succeed in preventing early criminal behaviour might be much larger. The estimated effects of early criminal behaviour and conduct disorder stress the importance of the early stages of life for preventing crime. Programs that keep children on 'the right track' not only may yield high private returns but also may yield high social returns through their impact on crime reduction. Studies on the effects of effective early schooling programs in the US show that these programs have large social returns mainly through their impact on preventing crime (Carneiro, et. al, 2003).

Our main conclusion is that the strong association between human capital and crime is mainly driven by the effect of early criminal behaviour on educational attainment. This finding based on within-twin estimation confirms one of the main conclusions from a synthesis of the literature on the causes of crime: 'We must rivet our attention on the earliest stages of the life cycle, for after all is said and done, the most serious offenders are boys who begin their criminal careers at a very early age.' (Wilson and Hernstein, 1985, cited in Dilulio, 1996).

1 Introduction

Many studies document a strong negative association between education and crime. For instance, in the US two-thirds of all incarcerated men in 1993 had not graduated from high school (Freeman, 1996). Studies that use self-reported and (administrative) arrest data find large differences in property and violent crime across education groups (Tauchen et al. 1994, Lochner, 2004). However, the relationship between crime and education is not straightforward. Does crime reduce investment in human capital or does education reduce criminal activity?

This paper studies the relationship between human capital and crime using data of a sample of young Australian twins. We exploit two aspects of the Australian survey data on education and crime. First, as the data are obtained from fraternal and identical twins, we are able to control for many unobserved characteristics affecting both criminal behaviour and schooling decisions. Second, as criminal behaviour is measured over different periods of time – prior to and after senior high school completion – we can address the causality between crime and education as well. As early criminal behaviour may affect human capital formation, and human capital may influence criminal behaviour in later stages of life, we follow a two step analysis.

First, we study the relationship between early crime and the accumulation of human capital. In particular, we estimate the effect of arrests before the age of 18 on educational attainment by using within-twin estimation. In addition, we investigate whether the timing of the arrest matters for educational attainment. Second, we estimate the effect of educational attainment on three measures of crime: incarceration, arrests since the age of 18 and number of arrests. As early criminal behaviour might be an important confounder in the estimation, we control for early arrests and measures of conduct disorder within pairs of twins.

Our paper contributes to the economic literature on the relationship between education and crime in several aspects. First, the empirical economic literature on human capital and crime that takes unobserved factors into account is limited. Two previous studies use arguably exogenous variation in human capital to investigate the effect of education on crime (Lochner and Moretti, 2004; Machin and Vujic, 2006). Both studies use changes in compulsory schooling laws as an instrument for educational attainment, so as to find that education reduces crime. We add to this literature and use an identification strategy that has not been applied before – that is, we exploit the longitudinal nature of our data so as to estimate the relationship between human capital and crime in both directions. Second, we investigate the effect of early criminal behaviour on investment in human capital while controlling for fixed effects within pairs of twins. We are not aware of studies in the economic literature that estimate the causal effect of early criminal activity on educational attainment. Third, there is growing interest in the economic literature for the effects of early conditions in life on adult outcomes (Currie and Stabile, 2006, 2007; Borghans, et. al, 2008). Our paper addresses similar issues.

We find early arrests (arrests before the age of 18) to have a strong effect on human capital accumulation. In particular, early arrests reduce educational attainment with .7 to .9 years of

education and lower the probability of completing senior high school with 20 to 23 percentage points. These effects are largely driven by the timing of the early arrest; arrests at age 13, 14 or 15 are most detrimental for educational attainment. We also find human capital to reduce crime. Completing senior high school reduces the probability of incarceration with 2 to 3 percentage points. Similar but statistically insignificant effects are obtained for the probability of being arrested since the age of 18 and for the number of arrests. When controlling for early arrests and early behaviour problems, the estimated effect of human capital on crime reduces to less than a quarter of the previously estimated association. The strong detrimental effects of early criminal behaviour become also transparent if we consider the estimated effects of early arrests on all three measures of crime. We then find large effects of early criminal behaviour on participation in crime later on. These effects are much larger than the (isolated) impact of human capital on crime.

We conclude that the strong association between human capital and crime is mainly driven by the effect of early criminal behaviour on educational attainment. Programs that succeed in preventing early criminal behaviour might yield high social and private returns.

2 Previous studies

The major difficulty in studying the relationship between human capital and crime is that both variables are driven by a multitude of unobserved factors. For instance, a person's level of schooling is typically not randomly determined but the result of individual choices and ability. These individuals might also have unobserved factors that prevent them from committing crimes. Unobserved factors that are both correlated with the decision to invest in human capital and the decision to participate in crime will confound the empirical relationship between education and crime. As such, OLS estimates of the effects of human capital on crime or OLS estimates of the effects of crime on human capital are likely to be biased.

The first part of this paper focuses on the effect of early criminal behaviour on human capital formation. To our knowledge there are no previous economic studies that empirically estimate the effect of early crime on investment in human capital while taking unobserved factors into account. Related studies can be found in health economics. Some recent studies investigate the effect of childhood mental health problems such as ADHD, aggression, anti-social behaviour and depression on human capital accumulation later in life (Le et al., 2005; Slade & Wissow, 2006; Currie & Stabile, 2006, 2007; Fletcher & Wolfe, 2007). These studies typically find large negative effects of childhood mental health problems on educational attainment. Another related literature focuses on the importance of cognitive and non-cognitive skills for labour market outcomes and social behaviour (Carneiro & Heckman (2003), Heckman et al. (2006), Heckman & Masterov (2007), Borghans et al. (2008)). These studies stress the importance of skills development early in life for human capital accumulation and success later in life. Early schooling programmes, like the Perry Preschool Programme (PPP), the Syracuse Programme (SP) or the Head Start Programme (HSP) have proven to be highly effective in reducing criminal activity, promoting socioeconomic skills, and integrating disadvantaged children into mainstream society (see for instance Schweinhart et al. 1993; Donohue & Siegelman, 1998; Lally et al. 1988; and Garces et al. 2002). These social, motivational, and emotional skills affect performance in school and in the workplace. Programmes that aim at intervening in the lives of children in their teenage years only attempt to redress the damage of bad childhoods (Carneiro & Heckman (2003)).

The second part of this paper studies the causal effect of human capital on crime. So far, only two papers in the economic literature try to establish a causal relationship between education and crime (Lochner & Moretti (2004), Machin & Vujčić (2006)). Both studies use changes in compulsory school leaving age laws in order to account for the endogeneity of schooling decisions. Using US Census data Lochner & Moretti (2004) show that one more year of schooling reduces the probability of incarceration by 0.37 percentage points for blacks, and 0.10 for whites. They corroborate these results using FBI Uniform Crime Reports (UCR) data for different types of offences, and conclude that the greatest impacts of graduation are associated with murder, assault, and motor vehicle theft. The authors also calibrate the social

savings from crime reduction associated with completing secondary education. They show that a 1% increase in male high school graduation rates would yield \$1.4 billion dollars in social benefits in 2004 dollars. Machin & Vujčić (2006) study the relationship between crime and education using two British data sources and making use of the raisings of the school leaving age that occurred in Britain in 1947 and 1973. These data sources are twofold: individual-level data on imprisonment from the 2001 Census, as well as cohort-level panel data on offending rates from the Home Office Offenders Index Data (OID) in the period from 1984 to 2002. The main finding is that schooling significantly reduces imprisonment rates and property crime offending. As mentioned before, these two studies use an instrumental variable approach and typically estimate a local treatment effect for the particular subgroup of the population that is affected by the instrument (a change in compulsory schooling). We expect that this subgroup consists of those at the lower end of the education distribution. Our approach (see next section) uses variation over the whole distribution of education which may bring the advantage that our estimates are applicable to a broader population. Theoretical work on the relationship between human capital and crime has been done by Lochner (2004). He developed a model of crime in which human capital increases the opportunity costs of crime. The model predicts that older, more intelligent and more educated adults should commit fewer street (unskilled) crimes. It is also expected that white collar crime should decline less with age and education than unskilled crime. These predictions receive broad empirical support in self-report data from the US.

3 Empirical strategy

In this paper, we use variation within pairs of twins for studying the relationship between education and crime. Obviously, the advantage of twin data is that many (unobserved) variables that twins share – like socioeconomic background and family factors – can be controlled for. Within twin estimation has been used in several studies on the returns to schooling (see for instance, Ashenfelter & Krueger, 1994, Miller, et al. 1995) and recently on the effect of parents' education on the education of their children (Behrman and Rosenzweig, 2005).

In order to get a full picture of the relationship between human capital formation and criminal behaviour, our estimation strategy consists of two steps. First, we focus on the relationship between early criminal behaviour and educational attainment. Early criminal behaviour is measured as the event of being arrested before the age of 18. It is likely that these early criminal activities occur during the time that the accumulation of human capital is still in progress because compulsory schooling laws force individuals in Australia to attend schooling until the age of 15 to 17, depending on the State of residence. For estimating the effect of early arrests on educational attainment we use the usual linear (probability) model for within-family estimation:

$$S_{ij} = \alpha + \beta A_{ij}^{17} + \gamma X_{ij} + f_j + \varepsilon_{ij} \quad (3.1)$$

where S_{ij} is the educational attainment of individual i in family j , A_{ij}^{17} is a dummy for being arrested before the age of 18, X_{ij} a vector of covariates, f_j is an unobserved family effect common to all twins in family j and ε_{ij} is a random error term. In this model the family fixed effect, which consists of all shared socioeconomic and genetic factors, is removed by differencing between twins. In equation (1), we expect that the causality primarily runs from early arrests towards educational attainment, as early arrests occur before the completion of schooling. We argue that we can largely control for reverse effects – i.e. bad school performance driving kids to start criminal activities – by including several measures of early school performance as additional controls. Moreover, we control for differences in early behaviour within pairs of twins by including an indicator of conduct disorder (see next section). The second part of our analysis addresses the effect of human capital on crime since the age of 18, which is usually the perspective that is taken in the literature. The model we estimate is very similar to equation (1):

$$C_{ij}^{18} = \alpha + \beta S_{ij} + \gamma X_{ij} + \delta A_{ij}^{17} + f_j + \varepsilon_{ij} \quad (3.2)$$

with C_{ij}^{18} is criminal activity since the age of 18. As early criminal activity is likely to be an important confounder for the estimated effect of human capital on crime, we include early

arrests as an additional control. We argue that these lagged arrests can be treated as exogenous variables.

Obviously, the twin setup – together with the use of lagged information – helps us to cancel out many possible sources of endogeneity. Still, there are two important concerns in the use of within-twin estimation (Bound & Solon, 1999) that need to be addressed to check the robustness of our results. First, measurement error in (self-) reported schooling (or crime) may bias the estimates towards zero ('attenuation bias'). A solution for this problem has been introduced by Ashenfelter and Krueger (1994). They obtained two measures of schooling of a twin by asking the twins to report both on their own schooling as on the schooling of their sibling. The second measure of schooling can then be used as an instrument to correct for measurement error. This approach has been used in several studies (for instance Miller et al. 1995, Behrman and Rosenzweig, 2005). In these studies, the size of the estimated effects increases after instrumenting for measurement error. This paper follows the same approach to address any attenuation biases.

The second concern in within-twin models is with respect to endogeneity bias within twin pairs. Although (identical) twins share many genes and were raised in the same social environment, they are not exactly identical. Bound and Solon (1999) show that the bias in the within-family estimator may not always be smaller than the bias in the cross-sectional estimator. This depends on the importance of the fixed family component in the unobservables. We address this possible bias by using additional controls in the within-twin models, such as conduct disorder and early arrests.

4 Description of data

We use data from the so-called younger cohort of twins of the Australian Twin Register (ATR). The ATR data were gathered in two surveys, in 1989-1990 and in 1996-2000. In 1980-1982 a sample of 4,262 twin pairs, born between 1964 and 1971, were registered with the ATR as children by their parents in response to media appeals and systematic appeals through the school system. The data were collected in two surveys among this sample of twins. In 1989-1992, when the twins were 18-25 years old, the first survey by mailed questionnaire was conducted, called Alcohol Cohort 2. The response rate of this questionnaire survey was 63%. In 1996-2000, the second survey was launched, called TWIN89. For this survey, telephone interviews were completed with 6,267 individuals, 2,805 men (889 complete and 1,027 incomplete pairs) and 3,462 women (1,215 complete and 1,032 incomplete pairs), who were 30 years old on average (range from 24 to 39) at the time of the interview. The individual response rate for this telephone interview was 86%.

The surveys gathered information on the respondent's family background (parents, siblings, marital status, and children), socioeconomic status (education, employment status, and income), health behaviour (body size, smoking and drinking habits), conduct disorder, personality, feelings and attitudes. Zygosity was determined by a combination of diagnostic questions plus blood grouping and genotyping.

The measures of crime used in the analysis are self reported data on arrests and incarceration. The survey contains questions on the age of first and last arrest, the number of arrests and incarceration. The questions explicitly exclude arrests for traffic violations, drunken behaviour or drunk driving. The question on incarceration excludes time spent in jail for using drugs or alcohol.

The reliability of these self-report data is an important issue. In criminology, the use of self report data is well established. Self-report has been the dominant technique used for measuring criminal behaviour since its introduction in the 1950s by Short and Nye (1957). A large literature shows that self-report data have consistently acceptable reliability and validity. Many studies find high correlations of self-report data with other criterion related measures of criminal frequency and arrest histories (Farrington, 1973; Hardt & Hardt, 1977; Horney & Marshall, 1992; Huizinga & Elliott, 1986; Maddux & Desmond, 1975; Mieczkowski, 1990; Weiss, 1998). Thornberry and Krohn (2000) conclude that 'self-reported measures of delinquency are as reliable as, if not more reliable than, most social science measures'. A recent study among street-drug users recruited in 11 cities throughout the United States revealed that lifetime arrest and incarceration items demonstrated good to excellent reliability (Fisher et al. 2004). In addition, it has been shown that substance abuse factors and mental illness factors did not affect the quality and accuracy of self-reported arrest history (Nieves et al. 2000).

Educational attainment was measured in the first survey using a seven point scale and translated into years of education (Miller et al., 1995). The second survey of the younger cohort

uses an eight point scale which we also translate into years of education (Miller, et al., 2006). We prefer to use this more recent measure, as it contains less missing values for our main estimation sample.

As covariates we use mothers and fathers education and age. In addition, we control for conduct disorder and early school performance. Our data contains self-reported information on 21 statements that reflect behavioural problems before the age of 18 (see Table A.1). In the second survey the twins were asked to reflect on their experiences before the age of 18. We constructed a measure of conduct disorder by summing occurrences of these 21 statements (see Vujic et al. 2008). This approach is similar to Currie and Stabile (2007) who use 6 questions to form a conduct disorder scale. The survey contains four questions on early school performance. Marks in primary and secondary education were measured using a three point scale: better than average, average and below average. Respondents were also asked about the teacher's view on their school achievements: did as well as could, could have done much better, don't know. Finally, grade repetition was measured.

In our total sample of 6267 individuals, 70 twins reported having spent time in jail and 340 twins reported having been arrested, which is 1.1% or 5.4% of our sample. Approximately 10% of male twins and 2% of female twins reported having been arrested. A direct comparison with population statistics is complicated because of differences in reporting measures. Statistics on alleged offenders in Australia for 1995 to 2005 show that among males aged 15-19 approximated 9 to 13% gets arrested and among females 2 to 3% (Australian Institute of Criminology, 2007). For individuals aged 20-24, the rates drop to 6 to 9% for men and 2% for women, for individuals older than 24 the rates drop further to approximately 1%. It should be noted that the number of alleged offenders does not equal the number of distinct offenders during a year because police may take action against the same individual for several offences, or the individual may be processed on more than one occasion for the same offence type. In addition, we might expect that many of those arrested since the age of 20 will be recidivists. As such, a direct comparison of the arrest rates found in our data with population statistics is difficult. However, the difference between males and females seem in line with the population statistics. In addition, the total arrest rates in our sample do not seem implausibly high or low.

The sample we use in the main estimations consists of pairs of twins with information on educational attainment and criminal participation. If this information is missing for one or both of the twins, we dropped the complete pair. In these samples, 47 twins reported having spent time in jail and 224 twins reported having been arrested. This includes 6 twin pairs (12 twins) who both report having spent time in jail and 28 twin pairs (56 individuals) who both report having been arrested. Our data contain information on the zygosity of the twins, enabling us to distinguish fraternal and identical twins. However, we only focus on the sample of all twins, including fraternal and identical twins. A separate analysis on the sample of identical twins strongly reduces the sample size and especially the variation within pairs of twins on the main variables of criminal behaviour. The intra-class correlation for being arrested (incarcerated) is

0.31 (0.41) for identical twins and 0.07 (0.13) for fraternal twins. Unfortunately, due to the routing of the questionnaire twins with a conduct disorder score of zero did not answer questions on criminal behaviour. As this may bias the estimates we did some sensitivity analysis with imputations for missing values on these outcomes for twins with no childhood conduct disorder (see section 7).

Table 4.1 Summary statistics for the main estimation samples

	Spent time in jail		Ever arrested	
	No	Yes	No	Yes
Education	11.9 (2.4)	10.3 (2.3)	12.0 (2.4)	11.0 (2.4)
Senior high school	75.0 (43.3)	36.2 (48.6)	76.7 (42.3)	52.2 (50.0)
Education (twin report)	11.7 (2.3)	10.2 (2.1)	11.7 (2.3)	10.9 (2.3)
Education father	10.4 (2.7)	9.5 (2.5)	10.4 (2.7)	9.9 (2.6)
Education mother	10.4 (3.1)	9.7 (2.9)	10.4 (3.1)	10.1 (2.8)
Male	53.1 (50)	85.1 (36)	51.1 (50.0)	78.1 (41.4)
Age in 1996	29.8 (2.5)	29.8 (2.7)	29.8 (2.5)	29.9 (2.5)
Conduct disorder	3.3 (2.5)	8.1 (3.4)	3.3 (2.4)	5.8 (3.4)
Marks primary school (1-3)	2.3 (0.6)	2.1 (0.7)	2.3 (0.6)	2.2 (0.6)
Marks secondary school (1-3)	2.2 (0.6)	2.0 (0.7)	2.2 (0.6)	2.0 (0.6)
Underachiever (%)	71.1 (45.3)	76.0 (43.1)	70.8 (45.5)	77.0 (43.1)
Grade repetition (%)	18.1 (38.5)	31.9 (47.1)	18.1 (38.2)	24.6 (0.43)
Age of first arrest	20.3 (4.6)	18.6 (4.7)		19.9 (4.7)
Identical twin	40.7 (49.1)	40.4 (49.6)	40.7 (49.1)	40.6 (49.2)
Estimation sample	2199	47	2028	224
Total sample	6197	70	5927	340

Table 4.1 shows sample means and proportions for educational attainment and background characteristics by criminal participation. The first two columns compare twins that spent time in jail with twins that have not been incarcerated. The last two columns compare twins that have ever been arrested with twins that have not been arrested. The sample size slightly differs between the first two columns and the last two columns because of missing values of

‘incarceration’ or ‘having been arrested’. Clearly, the sample statistics show a strong association between educational attainment and participation in crime. Twins that have been incarcerated attain on average 1.6 years less education than twins that have not been incarcerated. The difference in educational attainment between those that have been arrested and those that have not been arrested is on average 1 year. Very remarkable are the differences in completion of senior high school, especially between those who spent time in jail and those who did not. Two thirds of those who have been incarcerated did not graduate from senior high school, compared to only one quarter of the remaining group of those who have not been incarcerated. Twins that participated in crime have lower educated parents, the difference between the columns is larger for those who spent time in jail. Male twins are more likely to be involved in criminal activity.

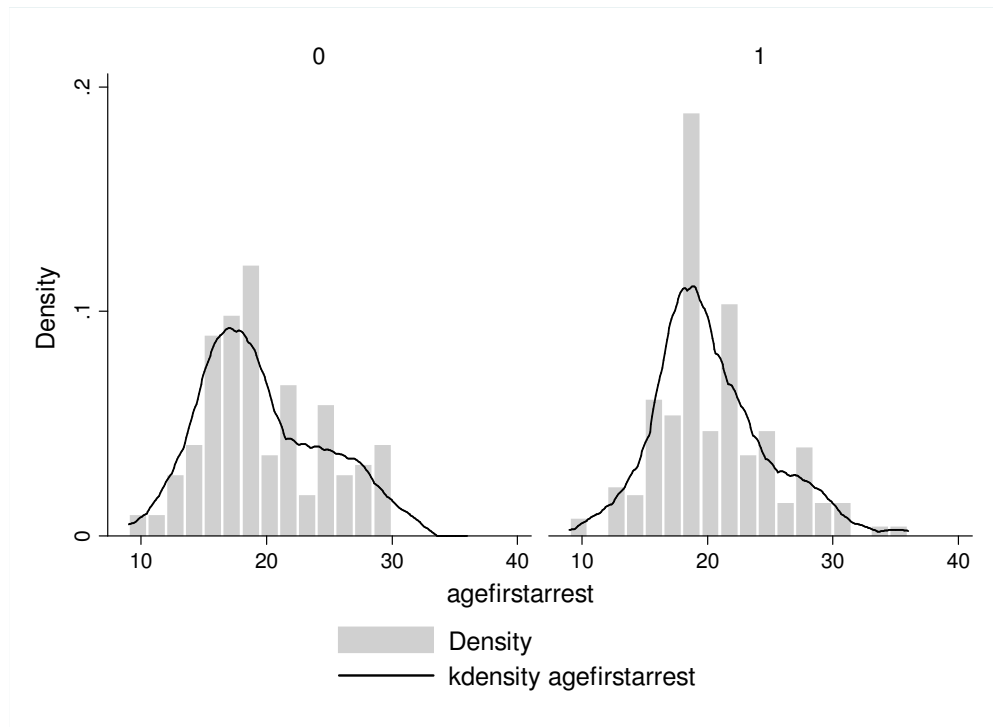
The bottom panel shows the statistics on conduct disorder and early school performance. The difference in conduct disorder is striking: twins that were incarcerated score approximately 5 points (2 standard deviations) higher on the indicator of conduct disorder. For twins that have been arrested this difference is more than two points. We also observe that twins that have been incarcerated or arrested have a higher grade repetition rate. The differences in self reported marks in primary and secondary school seem quite modest. Moreover, the first arrest occurs much earlier for twins that have been incarcerated than for other twins that have been arrested. We further explore the association between human capital and crime by looking at the relationship between education and arrests.

Table 4.2 Arrests by schooling level (%)

	Years of schooling					
	≤7	8-10	11-12	13	15	17
Ever arrested (%)	40	18.3	7.1	6.8	7.2	6.1
First arrest						
≤ 15 years	20	4	0.6	0.5	0.7	1.1
16 years	0	1.1	0.4	0	0.3	0.6
17 years	0	2.9	0.8	1.0	0	0
18 years	0	2.3	1.1	1.9	0.7	0.5
19 years	0	0.9	0.8	1.0	0.7	0.6
Ever arrested since 18 years	40	14.3	6.0	5.3	6.2	4.5
Number of arrests						
0	60	81.9	93.2	93.2	92.8	93.9
1	0	10.5	4.5	5.3	5.8	5.0
2	0	3.7	1.3	1.5	1.4	0.6
≥3	40	4.0	1.0	0	0	0.6
Spent time in jail (%)	20	5.1	1.1	0.5	1.4	0.6
N	5	574	995	207	292	179

Table 4.2 shows for each schooling level the proportions for several measures of criminal participation. Criminal participation is concentrated at the two lowest schooling levels. Twins that did not complete 11 years of education are more likely to be arrested and to be incarcerated. In addition, the number of arrests is higher for those with less than 11 years of education. We also observe that many arrests of those with less than 11 years of education already take place at an early age. Moreover, their arrest rates since the age of 18 are much higher than those for twins with at least 11 or 12 years of education. Table 2 also makes apparent that criminal participation is fairly stable for those with at least 11 or 12 years of education. This suggests a non linear relationship between human capital and crime. Completion of senior high school (11-12 years of education) seems to be a critical boundary in this respect. Lochner and Moretti (2004) report a similar nonlinear relation between education and crime for the US. In particular, they find a steep drop in criminal participation at the level of high school graduation.

Figure 4.1 Age of first arrest by schooling level



For many countries and time periods, it has well been established that crime rates increase during the teenage years, peak around the age of twenty and decrease afterwards (Lochner, 2004). This age-crime profile is well-documented in criminology. Figure 4.1 shows age-crime profiles from our data based on the self reported age of first arrest. The left figure shows an age-crime profile for individuals with less than 11 years of education. The right figure shows an age-crime profile for individuals who completed at least 11 years of education (senior high school).

The patterns in figure 4.1 confirm the typical features of age-crime profiles from the criminology literature. That is, participation in crime increases until the age of twenty and drops afterwards. A comparison of the left and right figures suggests that individuals with less than 11 years of education start earlier with criminal activities.

5 The effect of early arrests on educational attainment

The strong association between education and criminal activity might be the result of early participation in crime. Early criminal involvement might be detrimental for human capital investment because of various reasons such as ‘meeting the wrong friends (building criminal capital)’, ‘getting stigmatized’, changes in motivation or aspirations. In this section we investigate the effect of early arrest on human capital accumulation by estimating linear (probability) models of early arrests on education. Table 5.1 shows estimates of the effect of early criminal participation on human capital. We use the information on the age of first arrest as an indicator for early criminal participation and constructed a dummy for early arrests, which equals 1 (0) if someone had (not) been arrested before the age of eighteen. Column (1) shows the OLS-estimates of the effect of early arrests on educational attainment controlling for gender, age, age squared and education of parents. Column (2) includes conduct disorder as additional control. In column (3) additional controls for early school performance have been included: marks in primary school (1-3), marks in secondary school (1-3), grade repetition and teachers view on underachievement. Column (4) shows the fixed effect estimates controlling for gender, column (5) also controls for conduct disorder and column (6) also includes controls for early school performance. The top panel shows the effect of early arrests on years of education, the effects on completing senior high school are shown at the bottom of table 5.1.

Table 5.1 Estimates of the effect of early arrests on educational attainment

	OLS	OLS	OLS	FE	FE	FE
	(1)	(2)	(3)	(4)	(5)	(6)
Years of education						
Arrest before 18	- 1.534 (0.235)***	- 1.103 (0.236)***	- 0.954 (0.232)***	- 0.856 (0.329)***	- 0.740 (0.329)**	- 0.775 (0.318)**
Conduct disorder		- 0.120 (0.018)***	- 0.048 (0.018)***	(0.026)***	- 0.084 (0.026)*	- 0.050 (0.063)**
N	2252	2252	2252	2252	2252	2252
Twin Pairs				1126	1126	1126
Senior high school						
Arrest before 18	- 0.380 (0.055)***	- 0.297 (0.056)***	- 0.270 (0.055)***	- 0.230 (0.064)***	- 0.206 (0.064)***	- 0.212 (0.063)***
Conduct disorder		- 0.023 (0.004)***	- 0.014 (0.004)***	(0.005)***	- 0.017 (0.005)**	- 0.011 (0.012)***
N	2252	2252	2252	2252	2252	2252
Twin Pairs				1126	1126	1126

Note: All specifications control for gender. Column (1) and (2) control for age, age squared, education of parents, column (2) and (5) control for conduct disorder, column (3) and (6) also control for early school performance. Standard errors in brackets. ***/**/* significant at 1%/5%/10%-level.

All estimates in table 5.1 suggest that early arrests have a substantial impact on human capital accumulation. The cross sectional estimates show that those who are arrested before the age of 18 attain 1.0 to 1.5 less years of education and their probability of completing senior high school is 27 to 38 percentage points lower. The within-twin effects are smaller but remain large. Early arrests reduce educational attainment with .7 to .9 years and lower the probability of completing senior high school with 20 to 23 percentage points. Including conduct disorder reduces the effect of early arrests.¹ It should be noted that conduct disorder is closely related to early crime as the 21 statements used for measuring conduct disorder include items that can be considered as criminal (see table A.1). The estimates with the third specification are quite similar to the effects of the second specification.² Hence, including early school performance does not affect the estimates. This indicates that, conditional on conduct disorder, the findings are determined by early criminal behaviour, rather than differences in early school performance. Another remarkable finding in table 5.1 is the effect of conduct disorder, which is substantial for all specifications.

We further investigated the effect of the timing of the first arrest on education by constructing a second variable for early arrests. This variable measures the number of years before the age of 18 that the arrest took place (18 minus age first arrest). Table 5.2 shows the fixed effect estimates for models that include this arrest years variable and the square of this variable. Column (1), (2) and (3) show the estimates of the effect on years of education, column (4), (5) and (6) show the effect on completing senior high school. We use similar controls as in table 5.1.

Table 5.2 Estimates of the effect of the timing of the early arrest on educational attainment

	Years of education			Senior high school		
	FE (1)	FE (2)	FE (3)	FE (4)	FE (5)	FE (6)
18 minus age first arrest	- 0.080 (0.090)	- 0.652 (0.252)***	- 0.616 (0.243)**	- 0.037 (0.018)**	- 0.141 (0.049)***	- 0.126 (0.048)***
(18 minus age first arrest) squared		0.099 (0.041)**	0.097 (0.039)**		0.018 (0.008)**	0.016 (0.008)**
Conduct disorder			- 0.051 (0.026)**			- 0.012 (0.005)**
N		2252	2252		2252	2252
Twin Pairs		1126	1126		1126	1126

Note: All specifications control for gender. Columns (3) and (6) control for conduct disorder and early school performance. Standard errors in brackets. ***/**/* significant at 1%/5%/10%-level.

¹ In case of missing values on conduct disorder we included the value of the other twin. If both values were missing, we included the mean of the sample. In total we imputed values for 39 twins. We find similar results for the smaller sample without imputation.

² We imputed missing values on early school performance for 5 individuals. The results for the smaller sample without imputations are similar.

The estimates in table 5.2 corroborate the previous findings. The estimates show that the effect of early arrests also depends on the timing of the arrest, with earlier arrests being more detrimental for educational attainment. For instance, column (4) indicates that each year reduces the probability of high school completion with 3.7 percentage points. However, the estimates in column (5) and (6) suggest that the effect is not linear. Arrests at the age of 13, 14 or 15 are the most detrimental and reduce the probability of high school completion with more than 25 percentage points. Considering the fact that these arrests at age 13, 14 or 15 took place during compulsory education, these findings seem in line with our expectation that the causality runs from early arrests to human capital and not vice versa.

Summarizing, we find a large effect of early criminal behaviour on educational attainment, even when family fixed effects are taken into account. In addition, the timing of the early arrests matters, arrests at age 13, 14 or 15 are most detrimental for human capital accumulation.

6 The effect of human capital on crime

The second aspect of the strong association between education and criminal activity might be the effect of education on crime. Investments in human capital raise the opportunity costs of crime and may also alter preferences and discount rates. Previous studies for the US and the UK find evidence for a negative effect of education on crime (Lochner & Moretti, 2004; Machin & Vujic, 2006).

In this section, we analyze the effect of human capital on crime. The previous section showed that reverse causality cannot be ignored, as we found substantial effects of early criminal behaviour on educational attainment. We therefore include various controls in our model that are informative on criminal behaviour before the age of 18. First, the ‘early arrests’ variable (arrests before the age of 18) can be used as an obvious control. Second, we can also include the ‘conduct disorder’ variable, which is likely to precede investments in human capital.

We use the senior high school completion variable as our main measure of human capital. Senior high school can be completed at the age of 17 or 18. This brings the advantage that we can estimate the effect of completing senior high school on criminal activities since this age. The distinction between the investment in human capital and the timing of criminal activity would be less clear if we would use years of education as a measure of human capital instead. A second argument for using senior high school completion as a measure of human capital is that the effect of human capital on crime seems to be non linear (see table 4.2).

We investigate the effect of human capital on three self reported measures of crime: incarceration, arrests since the age of 18, and number of arrests. Unfortunately, our data do not contain information on the age of incarceration. However, statistics on incarceration in Australia show that the probability of being incarcerated before the age of 18 is very small.³ Arrests since the age of 18 are derived from the age of the last arrest. For the number of arrests we constructed a variable which has 4 categories (0; 1; 2; 3). All individuals that reported more than three arrests were include in the last category (52 individuals reported at least three arrests of which 22 reported exactly three arrest). The data only contain information on the age of the first and the age of the last arrest. Hence, for the other arrests it is not clear whether they took place after the completion of high school. Considering the evidence on reverse causality from the previous section we expect that this will give a downward bias for the estimates (more negative estimates).

Table 6.1 shows the estimates of the effect of completing senior high school on the three measures of crime, using linear probability models. The first three columns show OLS-estimates, the last three columns show estimates of fixed effect models using different controls. The top panel shows the effects on the probability of incarceration, the middle panel shows the

³ The rate of non-indigenous persons aged 10-17 in juvenile detention between 1994 and 2003 was between 16 and 26 per 100,000 of relevant population (Charlton and McCall, 2004). This is on average approximately 0.02 % of the population.

effect on the probability of being arrested since the age of 18 and the bottom panel shows the effect on the number of arrest (0-3).

Table 6.1 Estimates of the effect of high school completion on crime

	Incarceration					
	OLS			Within twin estimates		
	(1)	(2)	(3)	(4)	(5)	(6)
Senior high school	- 0.041 (0.010)***	- 0.020 (0.008)***	- 0.013 (0.008)*	- 0.038 (0.011)***	- 0.027 (0.011)***	- 0.023 (0.010)**
Arrest before 18		0.310 (0.057)***	0.281 (0.056)***		0.213 (0.023)***	0.202 (0.023)***
Conduct disorder			0.008 (0.002)***			0.008 (0.002)***
N	2246	2246	2246	2246	2246	2246
Twin pairs				1123	1123	1123
	Arrested since the age of 18					
	OLS			Within twin estimates		
	(1)	(2)	(3)	(4)	(5)	(6)
Senior high school	- 0.085 (0.016)***	- 0.065 (0.015)***	- 0.047 (0.015)***	- 0.037 (0.022)*	- 0.031 (0.022)	- 0.020 (0.022)
Arrest before 18		0.304 (0.059)***	0.234 (0.057)***		0.125 (0.048)**	0.103 (0.048)**
Conduct disorder			0.021 (0.003)***			0.018 (0.004)***
N	2252	2252	2252	2252	2252	2252
Twin pairs				1126	1126	1126
	Number of arrests					
	OLS			Within twin estimates		
	(1)	(2)	(3)	(4)	(5)	(6)
Senior high school	- 0.214 (0.034)***	- 0.104 (0.024)***	- 0.072 (0.023)***	- 0.108 (0.037)***	- 0.048 (0.034)	- 0.029 (0.033)
Arrest before 18		1.645 (0.111)***	1.522 (0.106)***		1.223 (0.073)***	1.183 (0.072)***
Conduct disorder			0.037 (0.006)***			0.033 (0.006)***
N	2250	2250	2250	2250	2250	2250
Twin pairs				1125	1125	1125

Notes: All columns control for gender, columns (2) and (3) control for age, age squared and education of parents

The OLS estimates show that education has a negative association with all three measures of crime. This association reduces substantially when including arrest(s) before 18 and conduct disorder. All fixed effect estimates in column (4) are statistically significant. Controlling for early arrests and conduct disorder substantially reduces the size of the estimates. This confirms the earlier findings on reverse causality. Only the estimates for the effects on incarceration remain statistically significant. Completing senior high school reduces the probability of incarceration with 2.3 percentage points. Hence, the fixed effects estimates suggest that the effect of human capital on crime is only moderate⁴.

The estimates for the effect of early arrests on the three measures of crime in table 6.1 are striking. The fixed effect estimates suggest that an early arrest increases the probability on incarceration with more than 20 percentage points and increase the probability of getting arrested since the age of 18 with 10 to 12 percentage points. In addition, the average number of arrests increases with approximately 0.2. The size of these effects is much larger than the estimated effect of completing senior high school. For instance, the estimated impact of being arrested before the age of 18 on incarceration is almost ten times higher than the estimated effect of high school completion. We also estimated the same models as in table 6.1 with years of education in stead of completing senior high school. The findings are quite similar to those in table 6.1 and suggest a small effect of human capital on crime after controlling for early arrests and conduct disorder (see table A.2 in the appendix).

We conclude that this section provides evidence for a negative but moderate effect of human capital on crime. Completing senior high school reduces the probability of incarceration with at least 2 percentage points. Human capital also reduces the probability of being arrested since the age of 18 and the number of arrests. Including early arrests and conduct disorder in the models substantially reduced the effect of human capital on crime. This confirms that reverse causality is an important issue. The most remarkable findings are the large effect of early arrests on all three measures of crime. These effects are substantially larger than the estimated effects of human capital.

⁴ As in the previous tables, we imputed values for 39 twins with missing data on conduct disorder. The estimation results on the smaller sample without the imputed values are similar.

7 Robustness

In this section, we investigate the robustness of the findings by addressing two issues. First, we test the sensitivity of the results by imputing missing values on criminal outcomes which are due to the routing of the questionnaire. Second, we address the issue of measurement error which is likely to bias the estimates downward.

7.1 Missing values due to the routing of the questionnaire

Due to the routing of the questionnaire, twins with a conduct disorder score of zero, which means that they reported negative on all 21 statements on conduct disorder before the age of 18, did not answer questions about arrests and incarceration. This may bias the estimates because this involves a large fraction of our sample (approximately 3000 observations). It seems likely that individuals that report no conduct disorder behaviour will be less involved in crime than those that have a positive conduct disorder score. For instance, the arrest (incarceration) rate of those with a conduct disorder score of 3 is 7.4 (0.6) against 2.5 (0.3) for those with a conduct disorder score of 1. We checked the sensitivity of the results by imputing zeros for twins with missing values on being arrested and incarceration. Tables 7.1 and 7.2 show the estimation results for the main models of the previous sections. Table 7.1 shows the results for the effect of early crime on educational attainment.

Table 7.1 Estimates of the effect of early arrests on educational attainment after imputations for missing values on early arrests

	OLS (1)	OLS (2)	OLS (3)	FE (4)	FE (5)	FE (6)
Years of education						
Arrest before 18	- 1.597 (0.215)***	- 0.876 (0.211)***	- 0.759 (0.205)***	- 0.803 (0.289)***	- 0.624 (0.291)**	- 0.668 (0.279)**
Conduct disorder		- 0.148 (0.014)***	- 0.071 0.0(13)***		- 0.079 (0.018)***	- 0.038 (0.018)**
N	5332	5332	5332	5332	5332	5332
Twin pairs				2666	2666	2666
Senior high school						
Arrest before 18	- 0.363 (0.052)***	- 0.254 (0.051)***	- 0.225 (0.050)***	- 0.189 (0.053)***	- 0.162 (0.054)***	- 0.163 (0.053)***
Conduct disorder		- 0.022 (0.003)***	- 0.014 (0.003)***		- 0.012 (0.003)***	- 0.006 (0.003)
N	5332	5332	5332	5332	5332	5332
Twin pairs				2666	2666	2666

Note: All specifications control for gender. Columns (1) and (2) control for age, age squared, education of parents, columns (2) and (5) control for conduct disorder, columns (3) and (6) also control for early school performance. Standard errors in brackets. ***/**/* significant at 1%/5%/10%-level.

The estimates in table 7.1 are somewhat smaller but quite similar to those in table 5.1. After the imputation of the missing values for being arrested we still find a large effect of early arrests on educational attainment.

Table 7.2 shows the estimates for the effect of high school completion on crime. The pattern of findings in table 7.2 is similar to the pattern in table 6.1. However, the estimates of the effect of high school completion on crime in the fixed effects model that uses all controls (column 6) becomes statistically insignificant. This suggests that the effect of educational attainment might be even smaller than indicated in table 6.1.

Table 7.2 Estimates of the effect of high school completion on crime after imputations for missing values on the crime variables

	Incarceration			Within twin estimates		
	OLS					
	(1)	(2)	(3)	(4)	(5)	(6)
Senior high school	- 0.021 (0.005)***	- 0.010 (0.004)**	- 0.005 (0.004)	- 0.016 (0.006)***	- 0.011 (0.006)*	- 0.008 (0.006)
Arrest before 18		0.291 (0.052)***	0.260 (0.051)***		0.204 (0.016)***	0.185 (0.016)***
Conduct disorder			0.007 (0.001)***			0.008 (0.001)***
N	5326	5326	5326	5325	5326	5326
Twin pairs				2663	2663	2663
	Arrested since the age of 18			Within twin estimates		
	OLS					
	(1)	(2)	(3)	(4)	(5)	(6)
Senior high school	- 0.054 (0.009)***	- 0.042 (0.009)***	- 0.025 (0.008)***	- 0.023 (0.012)*	- 0.020 (0.012)*	- 0.011 (0.012)
Arrest before 18		0.315 (0.054)***	0.218 (0.052)***		0.140 (0.033)***	0.094 (0.033)***
Conduct disorder			0.021 (0.002)***			0.021 (0.002)***
N	5332	5332	5332	5332	5332	5332
Twin pairs				2666	2666	2666
	Number of arrests					
	(1)	(2)	(3)	(4)	(5)	(6)
Senior high school	- 0.127 (0.020)***	- 0.065 (0.013)***	- 0.037 (0.013)***	- 0.158 (0.020)***	- 0.027 (0.018)	- 0.013 (0.018)
Arrest before 18		1.651 (0.101)***	1.491 (0.096)***		1.261 (0.050)***	1.184 (0.049)***
Conduct disorder			0.035 (0.004)***			0.036 (0.003)***
N	5330	5330	5330	5330	5330	5330
Twin pairs				2665	2665	2665

Notes: All columns control for gender, columns (2) and (3) control for age, age squared and education of parents.

We conclude that the estimates of the previous section are robust for imputing missing values of individuals with a conduct disorder score of zero. However, the estimated effect of high school completion on crime becomes statistically insignificant in models that control for early crime and conduct disorder.

7.2 Measurement error

A well-known concern in the literature using within-family models is measurement error (Griliches, 1979). By taking a within-family perspective, measurement error may exacerbate, which in turn is likely to bias the estimates towards zero. A solution for this problem has been proposed by Ashenfelter and Krueger (1994) in their study on the returns to schooling using data on twins. They suggested using a second independent measure of education as an instrument for educational attainment. In their study, they asked each sibling to report on both their own and their twin's schooling and used this information as independent measures of schooling. They constructed two instruments for the difference in education within twins depending on the assumptions about measurement error. Let S_1^1 refer to the self-reported education level of the first twin, S_1^2 to the sibling-reported education level of the first twin, S_2^2 to the self-reported education level of the second twin and S_2^1 to the sibling-reported education level of the second twin. The first instrument uses the difference in the twin's reports on the schooling of their sibling as an instrument for the difference in the report on the own schooling. Hence, $S_1^1 - S_2^2$ is instrumented with $S_1^2 - S_2^1$. The second instrument assumes that the measurement error of respondent's report on the own schooling and the schooling of their sibling is correlated. In the estimation, the difference in the reports of twin A about the own schooling and the sibling's schooling is instrumented with the difference in the reports of twin B on the sibling's schooling and the own schooling. Hence, $S_1^1 - S_2^1$ is instrumented with $S_1^2 - S_2^2$.

In our study, we can follow this approach in the models that estimate the effect of education on crime because our data include the same questions on the sibling's schooling. The correlation between the self-reported level of education and the sibling-reported education level, which indicates the reliability ratio, is 0.80. For high school completion this correlation is 0.63. It should be noted that this approach produces consistent estimates when the measurement error is classical. However, since our main variable (senior high school completion) is a binary indicator, the measurement error is non-classical. It has been shown that the IV-estimate will then be upward biased (Aigner, 1973, Kane et al. 1999). The within-family estimate from the previous analysis will then provide a lower bound and the IV estimate an upper bound of the true (negative) effect.

Table 7.3 shows the IV-estimates for the effect of high school completion on the three measures of crime. Columns (1), (3) and (5) show the estimation results for the first instrument

described above. Columns (2), (4) and (6) show the results for the second instrument. All specifications use early arrest, conduct disorder and gender as controls.

Table 7.3 IV-estimates of the effect of senior high school completion on crime

	Incarceration		Arrest since 18		Number of arrests	
	IV1	IV2	IV1	IV2	IV1	IV2
	(1)	(2)	(3)	(4)	(5)	(6)
Senior high school	- 0.199 (0.117)*	- 0.064 (0.024)***	- 0.231 (0.228)	- 0.081 (0.050)	- 0.401 (0.348)	- 0.115 (0.075)
N	2243	2243	2249	2249	2247	2247
Twin pairs	1123	1123	1126	1126	1125	1125

Notes: All columns control for gender, early arrest and conduct disorder. Standard errors in brackets. ***/**/* significant at 1%/5%/10%-level.

The estimates in table 7.3 suggest that measurement error in education might be important. All estimates increase and most estimates are statistically significant. The estimates with the first instrument are very large but also have large standard errors. The estimates with the second instruments are also larger than the estimates in table 6.1 but more precise. These results suggests that the findings in table 6.1 might underestimate the true effect of human capital on crime. We find a similar pattern when using years of education instead of completion of senior high school. However, the estimates are smaller (see table A.3 in the appendix). In addition, we re-estimated the models from table 7.3 after imputing the missing values for individuals with a conduct disorder score of zero (see table A.4 in the appendix). The size of the estimates is smaller after the imputation but the pattern of findings is quite similar.

Unfortunately, our data do not contain sibling reports on criminal behaviour. As such we can not use this approach for the models that investigate the effect of early crime on education. However, we can make a tentative assessment using external information on the reliability of self-reported crime and the intra class correlation in early crime measured in our sample of twins. Assuming classical measurement error Grilliches (1979) shows that within-family estimation increases the bias by measurement with $1 / (1 - \rho_c)$ with ρ_c as the intra class correlation in early crime within families. Thornberry and Krohn (2000) report that many studies find a reliability ratio of self reported crime well above 0.8. The intra class correlation in early crime in our data is 0.22. This means that the bias of the OLS-estimator is $-0.2*\beta$ and the bias of the fixed effect estimator is $-0.2/(1-0.22)*\beta = -0.26*\beta$. This calculation suggests that the additional downward bias of the within estimator is quite modest.

8 Decomposing the association between crime and education

The two main findings from the previous sections are that early criminal behaviour is detrimental to investment in human capital and that human capital has a negative effect on crime. In this section we try to assess the importance of these two effects for the association between crime and education. We estimated within-twin models of the effect of education on ‘ever being arrested’ and inspect how the estimated effect of education changes after including early crime and conduct disorder. Including ‘early arrests’ in the estimation controls for the effect of early criminal behaviour on educational attainment and ‘explains’ all arrests before the age of 18, leaving only crime since 18 to be explained. Table 8.1 shows the estimation results using years of education or high school completion as explanatory variables.

	(1)	(2)	(3)
Years of education	- 0.010 (0.005)**	- 0.004 (0.004)	- 0.003 (0.004)
N	2252	2252	2252
Pairs	1126	1126	1126
Senior high school	- 0.067 (0.024)***	- 0.026 (0.021)	- 0.018 (0.021)
N	2252	2252	2252
Pairs	1126	1126	1126
Controls			
Early arrest	No	Yes	Yes
Conduct disorder	No	No	Yes

Note: All columns control for gender. Standard errors in brackets. ***/**/* significant at 1%/5%/10%-level.

The estimates in the first column show that one year of education is associated with a reduction of the probability of being arrested with 1 percentage point. Completion of high school is associated with a reduction of the probability of being arrested with 6.7 percentage points. The estimates of the effect of human capital reduce dramatically after the inclusion of ‘early arrest’ (column (2)). The estimated effect of one year of education reduces to 0.4 percentage points and the estimated effect of high school completion to 2.6 percentage points. Including conduct disorder further reduces the estimated effects to 0.3 and 1.7 percentage points (column (3)). In other words, controlling for early arrests and early behaviour problems reduces the estimated effect of human capital on crime to less than one third of the previously estimated association. From this, we conclude that early criminal behaviour explains most of the association between human capital and crime.

9 Conclusions and discussion

This paper aims at disentangling the strong association between human capital and crime by investigating whether crime reduces investment in human capital or whether education reduces criminal activity. Heretofore, we exploit two aspects of the Australian survey data on education and crime we use. First, as the data are obtained from twins, we are able to control for many unobserved characteristics affecting both criminal behaviour and the schooling decisions. Second, as criminal behaviour is measured over different periods of time – prior to and after senior high school completion – we can address the causality between crime and education as well. As early criminal behaviour may affect human capital formation, and human capital may influence criminal behaviour in later stages of life, we follow a two step analysis.

First, we address the effects of early criminal behaviour on educational attainment. The estimates suggest that early criminal behaviour is detrimental to investment in human capital. Within pairs of twins we find that early arrests (before the age of 18) reduce educational attainment with .7 to .9 years and lower the probability of completing senior high school with 20 to 23 percentage points. In addition, the timing of the early arrest matters, arrests at age 13, 14 or 15 are most detrimental for educational attainment. These estimates are found after controlling for conduct disorder and early school performance.

Second, we focus on the effect of human capital on crime. As early criminal activity might be an important confounder, we control for early arrests. The estimates suggest that human capital has a negative effect on crime. Completing senior high school reduces the probability of incarceration with 2 to 3 percentage points. We find similar but statistically insignificant effects on the probability of being arrested since the age of 18 and on the number of arrests. The size of these estimates might be downward biased because of measurement error in schooling. IV-estimates using a second independent measure of schooling suggest that the effect of human capital might be larger. Lochner and Moretti (2004) report IV-estimates of the effect of high school completion on imprisonment of 8 percentage points for blacks and 0.9 for whites.

When combining these findings, it seems that the causality between human capital and crime runs in both directions. Still, the impact of early criminal behaviour on human capital formation dominates the impact of human capital formation on future crime behaviour. Controlling for early arrests and early behaviour problems reduces the estimated effect of human capital on crime to less than one third of the previously estimated association. From this, we conclude that early criminal behaviour explains most of the association between human capital and crime.

The strong detrimental effects of early criminal behaviour become also transparent if we consider the estimated effects of early arrests on all three measures of crime. Early arrests increase the probability of incarceration with 20 percentage points and the probability of being arrested since the age of 18 with 10 percentage points. These effects are much larger than the estimated effects of human capital. For instance, the estimated effect of being arrested before

the age of 18 on incarceration is almost ten times higher than the estimated effect of completing high school.

In line with previous studies (Lochner and Moretti, 2004, Machin and Vujic, 2006) our findings suggest that policies that succeed in raising investment in human capital might reduce crime. However, the (direct) returns to policies that succeed in preventing early criminal behaviour might be much larger. The estimated effects of early criminal behaviour and conduct disorder stress the importance of the early stages of life for preventing crime. Programs that keep children on 'the right track' not only may yield high private returns but also may yield high social returns through their impact on crime reduction. Studies on the effects of effective early schooling programs in the US show that these programs have large social returns mainly through their impact on preventing crime (Carneiro, et. al, 2003).

Our main conclusion is that the strong association between human capital and crime is mainly driven by the effect of early criminal behaviour on educational attainment. This finding based on within-twin estimation confirms one of the main conclusions from a synthesis of the literature on the causes of crime: 'We must rivet our attention on the earliest stages of the life cycle, for after all is said and done, the most serious offenders are boys who begin their criminal careers at a very early age.' (Wilson and Hernstein, 1985, cited in Dilulio, 1996).

References

- Aigner, D., 1973, Regression with a binary independent variable subject to errors of observation, *Journal of Econometrics* 1 (1973), pp. 49–60.
- Ashenfelter, O. and A. Krueger, 1994, Estimates of the Economic Return to Schooling from a New Sample of Twins, *The American Economic Review*, Vol. 84, No. 5, p. 1157-1173.
- Australian Institute of Criminology, 2007, Australian Crime, Facts & Figures 2007, Canberra, Australia.
- Behrman, J. R., P. Taubman and T.J. Wales, 1977, Controlling for and Measuring the Effects of Genetics and Family Environment in Equations for Schooling and Labour Market Success, in Paul Taubman, ed., *Kinometrics: The Determinants of Socioeconomic Success within and between Families*, Amsterdam: North Holland, p. 35-96.
- Bound, J. and G. Solon, 1999, Double trouble: on the value of twins-based estimation of the return to schooling, *Economics of Education Review*, Vol. 18, p. 169-182.
- Borghans, L., A.L. Duckworth, J.J. Heckman and B. ter Weel, 2008, The Economics and Psychology of Personality Traits, *Journal of Human Resources*, Vol. 43, No. 4, forthcoming.
- Borghans, L., H. Meijers and B. ter Weel, 2008, The role of non-cognitive skills in explaining cognitive test scores, *Economic Inquiry*, Vol. 46, No. 1, p. 2-12.
- Carneiro, P. and J.J. Heckman, 2003, Human Capital Policy, in J. J. Heckman, A. B. Krueger and B. M. Friedman (Eds.), *Inequality in America: What Role for Human Capital Policies?* Cambridge, MA: MIT Press.
- Charlton, K. and M. McCall, 2004, Statistics on juvenile detention in Australia: 1981-2003, Australian Institute of Criminology.
- Currie, J. and M. Stabile, 2006, Child Mental Health and Human Capital Accumulation: The Case of ADHD, *Journal of Health Economics*, Vol. 25, No. 6, pp. 1094-1118.
- Currie, J. and M. Stabile, 2007, Mental Health in Childhood and Human Capital, NBER Working Paper, WP 13217.

- Donohue, J. and P. Siegelman, 1998, Allocating Resources among Prisons and Social Programmes in the Battle against Crime, *Journal of Legal Studies*, Vol. 27, No. 1, p. 1-43.
- Farrington, D., 1973, Self-reports of deviant behavior: Predictive and stable?, *Journal of Criminal Law and Criminology*, 64(1): 99-110.
- Fisher, D.G., G.L. Reynolds, M.M. Wood and M.E. Johnson, 2004, Reliability of Arrest and Incarceration Questions on the Risk Behaviour Assessment, *Crime & Delinquency*, Vol. 50, No. 1, 24-31.
- Fletcher, J. and B.L. Wolfe, 2007, Child Mental Health and Human Capital Accumulation: The Case of ADHD Revisited, NBER Working Paper, WP 13474.
- Freeman, R. B., 1996, Why Do So Many Young American Men Commit Crimes and What Might We Do about It?, *Journal of Economic Perspectives*, American Economic Association, Vol. 10(1), pp. 25-42.
- Garces, E., D. Thomas and J. Currie, 2002, Longer-Term Effects of Head Start, *American Economic Review*, Vol. 92, No. 4, pp. 999-1012.
- Griliches, Z., 1979, Sibling models and data in economics: beginnings of a survey, *Journal of Political Economy*, 87(5), pp. S37-S64.
- Hardt, R., & S. Hardt, 1977, On determining the quality of the delinquency self-report method, *Journal of Research in Crime and Delinquency*, July: 247-257.
- Heckman, J. J., J. Stixrud and S. Urzua, 2006, The Effects of Cognitive and Non-cognitive Abilities on Labour Market Outcomes and Social Behaviour, *Journal of Labour Economics*, Vol. 24, No. 3, p. 411-481.
- Heckman, J. J. and D.V. Masterov, 2007, The Productivity Argument for Investing in Young Children, IZA Discussion Paper 2725.
- Horney, J. and I. Marshall, An experimental comparison of two self-report methods for measuring lambda, *Journal of Research in Crime and Delinquency*, 29(1): 102-121.
- Horney, J. and I.H. Marshall, 1992, Risk perceptions among serious offenders: the role of crime and punishment, *Criminology* 30, pp. 575-594.

- Huizinga, D. and D.S. Elliott, 1986, Reassessing the reliability and validity of selfreport delinquency measures, *Journal of Quantitative Criminology*, 2, 293-327.
- Kane, T.J., C.E. Rouse and D. Staiger, 1999, Estimating returns to schooling when schooling is misreported, Working paper 419, Princeton University.
- Lally, J. R., P. Mangione and A. Honig, 1988, The Syracuse University Family Development Research Programme: Long-Range Impact on an Early Intervention with Low-Income Children and Their Families, In *Parent Education as Early Childhood Intervention*, Douglas Powell, ed. Norwood, N.J.: Ablex.
- Le, A. T., P.W. Miller, A.C. Heath and N. Martin, 2005, Early childhood behaviors, schooling, and labour market outcomes: estimates from a sample of twins, *Economics of Education Review*, Vol. 24, p. 1-17.
- Lochner, L, 2004, Education, Work and Crime: A Human Capital Approach, *International Economic Review*, 45, 811-843.
- Lochner, L. and E. Moretti, 2004, The Effect of Education on Crime: Evidence from Prison Inmates, Arrests, and Self-Reports, *American Economic Review*, 94, 155-189.
- Machin, S. and S. Vujic, 2006, Crime and Education: New Evidence From Britain, CEP Working Paper.
- Maddux J. and D. Desmond, 1975, Reliability and validity of information from chronic heroin users, *Journal of Psychiatric Research*, 12(2): 87-95.
- Mieczkowski, T., 1990, The accuracy of self-reported drug use: An evaluation and analysis of new data, in R. Weisheit (Ed.), *Drugs, crime and the criminal justicesystem*, pp. 275-302, Cincinnati: Anderson.
- Miller, P., C. Mulvey and N. Martin, 1995, What Do Twins Studies Reveal about the Economic Return to Education? A Comparison of Australian and U.S. Findings, *American Economics Review*, Vol. 85, No. 3, pp. 586-599.
- Miller, P., C. Mulvey and N. Martin, 2006, The return to schooling: Estimates from a sample of young Australian twins, *Labour Economics*, 13, pp. 571-587.

- Nieves, K., J. Draine and P. Solomon, 2000, The Validity of Self-Reported Criminal Arrest History Among Clients of a Psychiatric Probation and Parole Service, *Journal of Offender Rehabilitation*, Vol. 30 (3/4), 2000, pp. 133-151.
- Schweinhart, L., H. Barnes and D. Weikart, 1993, *Significant Benefits: The High-Scope Perry Pre-School Study through Age 27*, Ypsilanti, Mich.: High Scope Press.
- Short, J.F. and I. Nye., 1957, Reported behavior as a criterion of deviant behavior, *Social Problems*, 5, 207-213.
- Slade, E.P. and L.S. Wissow, 2007, The Influence of Childhood Maltreatment on Adolescents, Academic Performance, *Economics of Education Review*, Vol. 26, No. 5, pp. 604-614.
- Tauchen, H., A.D. Witte and H. Griesinger, 1994, Criminal deterrence: Revisiting the issue with a birth cohort, *Review of Economics and Statistics*, 76(3), pp. 399-412.
- Thornberry, T.P. and M.D. Krohn, 2000, The self-report method for measuring delinquency and crime, *Criminal Justice 2000*, vol. 4, pp. 33-83.
- Vujic, S., H.D. Webbink and P. Koning, 2008, The effect of childhood conduct disorder on human capital, CPB Discussion Paper.
- Weiss, R., L. Najavits, S. Greenfield, J. Soto, S. Shaw and D. Wyner, 1998, Validity of substance use self-reports in dually diagnosed outpatients, *American Journal of Psychiatry*, 155, 127-128.
- Wilson, J.Q., and R.J. Herrnstein, 1985, *Crime and human nature*, New York: Simon and Schuster.

Appendix

A1. Variable Definitions

Table 9.1 Conduct disorder statements from the TWIN89 questionnaire	
Variable	Question
misbehaved	L3 Did you <u>frequently</u> get into a lot of trouble with the teacher or principal for misbehaving in school? (primary or secondary school)
wagged school	L4 Before age 18, did you ever wag school for an entire day at least twice in 1 year?
suspended/expelled	L5 Were you ever suspended or expelled from school?
stay out late	L6 As a child or a teenager, did you <u>often</u> stay out <u>much later</u> than you were supposed to?
sneak out at night	L6A Did you <u>often</u> sneak out of the house at night?
run away overnight	L6C Before age 18, did you ever run away from home <u>overnight</u> ?
lied, used false name	L7 Before 18, did you ever tell <u>a lot</u> of lies or use a false name or alias?
outsmarted, conned others	L7B Before age of 18, was there ever a period when you often outsmarted others and “conned” them?
stole from home or family	L8 Before age 18, did you steal money or things from your home or family more than once? If yes, did you only steal things of trivial value, like loose change or things like that?
shoplifted	L8A Before age 18, did you steal or shoplift from shops or other people (without their knowing) more than once? If yes, did you only steal things of trivial value like comics or lollies?
forged signature	L8B Before age 18, did you forge anyone’s signature on a cheque or credit card more than once?
damaged property	L9 Have you ever damaged someone’s property <u>on purpose</u> ?
started physical fights	L10 Before age 18, did you <u>start</u> physical fights (with persons <u>other than</u> your brothers or sisters) 3 or more times?
used a weapon	L11 Before age 18, did you ever use a weapon like a bat, brick, broken bottle, gun or a knife (other than in combat, when hunting, or as part of your job) to threaten or harm someone?
physically injured someone	L12 Before age 18, (other than fighting or using a weapon) did you ever physically injure anyone on purpose?
bullied others	L13 Before age 18, were you <u>often</u> a bully, deliberately hurting or being mean to others?
mean to animals	L14 Before age 18, were you ever mean to animals including pets or did you hurt animals on purpose?
lighted fires	L15 Before 18, did you ever deliberately light any fires you were not supposed to?
broke into someone’s car/house	L16 Before 18, did you ever break into someone’s car or house or anywhere else (not because you were locked out)?
forcefully stole money or property	L17 Before age 18, did you ever take money or property from someone else by threatening them or using force, like snatching a purse or robbing them?
forced someone into sexual activity	L20 Before age 18, did you ever force anyone into intercourse or any other form of sexual activity?

Table A.2 Estimates of the effect of years of education completed on crime

	Incarceration			Within twin estimates		
	OLS					
	(1)	(2)	(3)	(4)	(5)	(6)
Years of education	- 0.006 (0.002)***	- 0.003 (0.001)**	- 0.001 (0.001)	- 0.004 (0.002)*	- 0.002 (0.002)	- 0.001 (0.002)
Arrest before 18		0.313 (0.057)***	0.284 (0.056)***		0.218 (0.023)***	0.205 (0.023)***
Conduct disorder			0.009 (0.002)***			0.009 (0.002)***
N	2246	2246	2246	2246	2246	2246
Twin pairs				1123	1123	1123
	Arrest since 18			Within twin estimates		
	OLS					
	(1)	(2)	(3)	(4)	(5)	(6)
Years of education	- 0.012 (0.003)***	- 0.009 (0.003)***	- 0.006 (0.003)**	- 0.006 (0.004)	- 0.005 (0.004)	- 0.003 (0.004)
Arrest before 18		0.314 (0.059)***	0.242 (0.057)***		0.128 (0.048)***	0.104 (0.048)**
Conduct disorder			0.021 (0.003)***			0.018 (0.004)***
N	2252	2252	2252	2252	2252	2252
Twin pairs				1126	1126	1126
	Number of arrests			Within twin estimates		
	OLS					
	(1)	(2)	(3)	(4)	(5)	(6)
Years of education	- 0.032 (0.006)***	- 0.016 (0.004)***	- 0.010 (0.004)**	- 0.019 (0.007)***	- 0.011 (0.007)	- 0.007 (0.007)
Arrest before 18		1.660 (0.111)***	1.532 (0.106)***		1.225 (0.073)***	1.184 (0.072)***
Conduct disorder			0.038 (0.006)***			0.032 (0.006)***
N	2250	2250	2250	2250	2250	2250
Twin pairs				1125	1125	1125

Notes: All columns control for gender, columns (2) and (3) control for age, age squared and education of parents.

Table A.3 IV-estimates of the effect of years of education on crime

	Incarceration		Arrest since 18		Number of arrests	
	IV1	IV2	IV1	IV2	IV1	IV2
	(1)	(2)	(4)	(5)	(1)	(2)
Senior high school	- 0.005 (0.005)	- 0.003 (0.003)	- 0.006 (0.010)	- 0.007 (0.007)	- 0.008 (0.015)	- 0.008 (0.011)
N	2243	2243	2249	2249	2247	2247
Twin pairs	1123	1123	1126	1126	1125	1125

Notes: All columns control for gender, early arrest and conduct disorder. Standard errors in brackets.

Table A.4 IV-estimates of the effect of high school completion on crime after imputating missing values

	Incarceration		Arrest since 18		Number of arrests	
	IV1	IV2	IV1	IV2	IV1	IV2
	(1)	(2)	(4)	(5)	(1)	(2)
Senior high school	- 0.106	- 0.030	- 0.117	- 0.061	- 0.283	- 0.094
	(0.066)	(0.013)**	(0.130)	(0.026)**	(0.202)	(0.039)**
N	5322	5322	5328	5328	5326	5326
Twin pairs	2663	2663	2666	2666	2665	2665

Notes: All columns control for gender, early arrest and conduct disorder. Standard errors in brackets. ***/**/* significant at 1%/5%/10%-level.
