The Impact of Maternal Imprisonment on Children's Educational Achievement

Results from Children in Chicago Public Schools

Rosa Minhyo Cho

ABSTRACT

This paper examines how the cognitive skills of elementary school-aged children are affected by having a mother enter prison, using panel data on approximately 7,000 children for 12 years. To identify the effect of maternal imprisonment, change in test scores of children whose mothers enter prison are compared with the change in test scores of a nonexperimental comparison group controlling for observed and unobserved fixed characteristics. Results suggest that maternal imprisonment is not associated with a decline in children's reading or math standardized test scores.

I. Introduction

The number of prisoners in the United States has more than tripled between 1980 and 2005. At midyear 2006 about 1.6 million prisoners were under

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Federal and State jurisdiction, with the proportion of female inmates rising at a much higher rate than male inmates (Sabol, Minton, and Harrison 2007).[1] About 100,000 women are estimated to enter prison annually with about a quarter million children left behind (Harrison and Beck 2005).

Although previous research suggests imprisonment to be effective in reducing overall crime rates (Levitt 1996), it is unclear whether the current prison population has already surpassed what may be optimal. Levitt's estimation relies on average values, and fails to consider whether the marginal benefit of an additional prisoner in fact outweighs the marginal cost (Levitt 1996).

This is of particular concern since the majority of increase in the prison population of both men and women has been due to increased conviction rates and harsher sentencing related to nonviolent crimes such as drug offenses, with no evidence that such policies have been effective in actually reducing incidences of drug abuse (Blumstein 1993). I look specifically to the case of women with children because this class of prisoners is more likely to fit the profile of the marginal prisoner. Women inmates are more likely than male inmates to have been incarcerated for nonviolent drug crimes (Snell 1994). According to data from the Illinois Department of Corrections (IDOC), the two most popular offense categories of female inmates incarcerated between 1990 and 2001 are controlled substance violation (41 percent) and retail theft (17 percent). Only an insignificant minority of women were imprisoned for crimes committed against their own children.[2] About 83 percent of the women are reported to have children at the time of prison entry.[3] Few women are repeat offenders; About 63 percent of the Illinois women entered prison only once during the sampling period. As such, women are more likely to be on the margin for imprisonment with questionable benefits derived therefrom.

Even from the cost side of the equation, the class of female prisoners may provide a more compelling story. Consider that women are usually the primary caregivers to minor children.[4] Intuitively, the harm to the family and children caused by maternal incarceration may be greater in the case of mothers imprisoned for drug offenses or retail theft (picture a mother stealing from a grocery store to feed her children) compared to those imprisoned for child abuse. However, the overall effect, or net cost, of incarcerating an additional woman is not so intuitive. Children could suffer from this experience due to parent-child separation, trauma, shame, and stigma, although they

1. The number of female prisoners under the jurisdiction of State or Federal authorities increased from 12,331 in 1980 to 111,403 in 2006. Women accounted for 7.2 percent of all inmates at midyear 2006, up from 6.1 percent at yearend 1995.

2. In 1991, less than 1 percent of female incarceration in U.S. State prisons was due to kidnapping or child abuse (Snell 1994). I find similar results in the IDOC data.

3. The percentage of women with minor children should be slightly lower since some of the children will be above 18 years old.

4. Snell (1994) finds that about 78 percent of female and 64 percent of male prisoners have children, while 67 percent of female and 56 percent of male prisoners have children under the age of 18. Greenfeld and Snell (1999) report that about 64 percent of women inmates in state prison with minor children had lived with those children prior to admission, while only 44 percent of men had resided with their children. Mumola (2000) reports that after incarceration of mothers, grandparents care for more than 50 percent of children, while the fathers assumes responsibility only 28 percent of the time, and about 10 percent of the children go into foster care. On the other hand, when a father is incarcerated, the child's mother, also the caregiver prior to the father's arrest, continues with the responsibility 90 percent of the time.

also may be better off by being removed from a negligent, violent, or abusive mother (Hagan and Dinovitzer 1999).

This study attempts to better understand the effects of maternal incarceration in State prison on children's outcomes. As explained above, in theory, the effects of maternal incarceration on children are at best ambiguous. Prior research examining the impact of maternal incarceration on children suggests negative effects, especially in terms of educational outcomes (Beatty 1997; Dallaire 2007; Fritsch and Burkhead 1981; Johnston 1995; Kampfner 1995; Myers and Hagen 1999; Seymour 1998; Parke and Clarke-Stewart 2001). However, most of these studies fail to account for the selection of children who have incarcerated mothers.

I examine the effect of maternal imprisonment on children's cognitive skills measured by reading and math standardized test scores. The study uses a nonexperimental comparison group composed of children whose mothers enter a local jail once for a brief time period (as opposed to mothers actually imprisoned) to examine the relationship between maternal imprisonment and the cognitive development of children in elementary school. Data are from multiple years of Chicago Public School (CPS) data, Illinois Department of Corrections (IDOC) data, and Cook County Jail (CCJ) data. I find that children who are under maternal guardianship prior to their mother's prison entry do not experience a decrease in reading or math test scores. Although the overall test scores of children in the prison group are slightly lower than test scores of children in the comparison group, there is no significant difference in the change in test scores between the two groups relative to the timing of their mother's incarceration. The findings suggest that loss in children's cognitive skills is not a direct result of, and thus not a cost of, maternal imprisonment.

The remainder of this paper is organized as follows. Section II reviews the previous literature on the effect of maternal incarceration. Section III explains how the comparison group sample is constructed. Section IV describes the data, and Section V explains the empirical strategy. Section VI presents findings on the effect of maternal imprisonment on children's test scores. Section VII presents a specification check on the results and Section VIII concludes with a cost-benefit analysis of maternal imprisonment.

II. Previous Research

The literature on children of imprisoned mothers generally suggests that maternal imprisonment can negatively affect the emotional, behavioral, and psychological development of children. According to many developmental psychologists, a mother's prison incarceration is detrimental to children of all age groups because factors such as parent-child separation, trauma, and shame, or stigma negatively influence the child left behind (Johnston 1992). Sociological theorists point to the harm it casts on the child's socialization process. They argue that the social control of children by parents is an important source of social capital, and that children with incarcerated mothers are more likely to lack adequate parental supervision, role models, and support in their socialization process (Hagan and Dinovitzer 1999).

One of the most researched outcome variables in this field of study has been the change in children's educational performance following the event of maternal

imprisonment. Studies have found that upon such an event, children become disruptive in the classroom, or exhibit other forms of antisocial behavior. Academic performance often deteriorates and such children develop other school-related difficulties (Beatty 1997; Fritsch and Burkhead 1981; Hagen and Myers 2003; Johnston 1995; Kampfner 1995; Myers *et al.* 1999; Seymour 1998; Parke and Clarke-Stewart 2001). Children with incarcerated mothers are more likely than their peers to become suspended from school, require mandated school visits by their guardian, fail classes, and undergo extensive periods of absence (Johnston 1995; Myers *et al.* 1999). Reactions to the trauma of maternal incarceration entail aggressive behavior within the classroom and lack of concentration. The Children of Offenders Study (Johnston 1992) found that these problems typically appear during elementary school, especially in Grades 4 and 5. Without appropriate mechanisms to cope with such trauma, many of these children fall into delinquency and adult crime themselves (Dallaire 2007).

The existing literature goes further to show that the magnitude of impact depends on varying circumstances, including age, length of separation, strength and nature of the mother-child relationship, and the existence of alternate care-giving arrangements. For example, Johnston (1995) identifies different effects of incarceration relative to the child's stage of development, and finds that children in their early childhood (two to six years of age) may be the most impacted by separation from their mothers. T.E. Hanlon *et al.* (2005) find children of incarcerated addict mothers to be neither especially deviant nor maladjusted, mainly because most incarcerated addict mothers were not their primary caregivers. And, finally, Gaudin and Sutphen (1993) investigate the differences in quality of care provided to these children after their mother's imprisonment. They compare children in foster care families to children living with an extended family member (usually grandmothers), and find that foster care families provide significantly better care for children between the ages of three and six and no less quality care to children in other age groups.

Despite the many attempts to identify how children react to maternal imprisonment, there have been few empirical longitudinal studies. Most of the prior research consists of theoretical predictions based on psychology, criminology, and sociology. To the extent there exist any meaningful empirical analyses, such studies are limited to data from surveys or interviews of, at best, a small single cohort sample of incarcerated mothers.[5] Many children whose mothers are incarcerated have already been exposed to parental (for example, substance abuse, mental health problems) and environmental (for example, poverty, parents' criminal behaviors, community violence) risk factors prior to their mother's incarceration (Johnson and Waldfogel 2002). Furthermore, these risk factors interact with each other and change over time (Johnson and Waldfogel 2002). Such empirical analyses, therefore, are unable to isolate any causal effects between maternal imprisonment and changes in children's outcomes. Without appropriate controls for these special circumstances, previous studies fail to assess the proper magnitude of maternal imprisonment's impact on

5. For example, the T. E. Hanlon *et al.* (2005) study cited above was based on self-reported interview data on 88 children from 88 incarcerated mothers in Maryland. For each mother, Hanlon selected only one child between the ages of nine and 14 for the study. If more than one child fell into the range of 9-14 years-old, Hanlon selected the one closest to age 11.

children. Even assuming that previous research identifies the correct sign of impact, consider the possibility of over- or underestimation given the positive or negative change in the child's life following the mother's prison entry.

This paper contributes to the literature in several important ways. The most elementary yet most empirically significant addition is that this paper analyzes longitudinal data on a large population-based sample. Specifically, I use panel data on 6,862 elementary school-aged children spanning 12 years. The data also contains information on the children's reading and math test scores, the type of guardianship during the years surrounding maternal incarceration, as well as detailed background characteristics of both the child and the mother, allowing for a more appropriately controlled analysis. Finally, this paper formulates one of the most interesting questions about criminal justice policy from within a marginal cost-benefit framework. I attempt to shed new light on the additional cost related to incarcerating the marginal prisoner through the illustration I use here: incarcerated mothers with children.

III. Solving the Evaluation Problem—Constructing the Comparison Group

The effects of maternal imprisonment could be easily estimated if it were possible to observe the child simultaneously under both situations, when the mother is sent to prison and when the mother is not sent to prison. The impact on such a child may then be measured by the difference in subsequent academic performance between the two scenarios. However, an evaluation problem arises due to the fact that we do not observe the counterfactual outcome: the academic performance of children with imprisoned mothers had their mothers not been imprisoned. I am forced to rely on statistical tools to create a comparable counterfactual.

I construct a comparison group from a set of children whose mothers enter Cook County Jail (CCJ) on a single-time basis between January 1, 1993 and June 30, 2001. I look at those mothers who stay in CCJ for a period of three days or less on that single occasion.[6] On the other hand, the observed ''treatment'' group (hereinafter, ''prison group'') is a set of children whose mothers enter prison rather than just spend a few nights in county jail. These mothers have been admitted to the Illinois Department of Corrections (IDOC) at least once (and in some cases on a number of occasions) during the same sampling period. The impact of maternal im''prison''ment is defined as the difference between these two groups in the change of test scores upon the event of maternal incarceration (in one case, jail; the other, prison).

An advantage of using a comparison group composed of children who experience maternal incarceration in a local jail albeit for a very short time is that it will prevent us from overestimating the true impact of maternal imprisonment.[7] The prison group children are compared with children of mothers who may not have ever seen prison,

6. The impact of maternal imprisonment does not change when estimated with a larger comparison group composed of children whose mothers enter CCJ for a period of up to seven days.

7. For purposes of this paper, I use the term ''incarceration'' to include both admission to jail or prison, whereas the term ''imprisonment'' only refers to admission to prison.

but nevertheless possess similar background characteristics—that is, family composition, race, income, and parental education. This also translates into reduced selection on unobservable characteristics. The child of an imprisoned mother should be more comparable to the child of a mother who has at one time in her life been to county jail, more so than a mother who has never been arrested.

Despite these similarities, however, the prison versus jail group strategy is effective because inmates in jail are very different from inmates in prison, especially those that spend three days or less in jail on a single-time basis.[8] Not only are inmates in prison serving longer sentences and committed for more serious crimes, they all have been housed in jail at least once (multiple times in most cases) prior to their imprisonment. The comparison group at hand is comprised mostly of women with minor offenses that generally never end up convicted of their crime and are released within a couple of days. As a result, the amount of time they are forced to spend apart from their children is minimal, if any.

Thus, I assume the comparison group children to have not suffered any inherent impact of maternal incarceration itself (whether jail or prison) because of their mothers' relatively short jail stay. However, if children suffer symptoms arising from maternal incarceration due to any reasons other than the separation itself, such as trauma, shame, or stigma, the prison effect would be underestimated. Yet, prior research suggests the separation factor to be the most damaging aspect of women's incarceration because it presents multiple barriers associated with maintaining a healthy mother-child relationship (Covington and Bloom 2003). The limited contact with their children during confinement is the main source of strain in the relationship even after release (Arditti and Few 2006). Furthermore, it is frequently the case that the children are not told about their mother's incarceration especially when she is not absent for extended time periods (Fritsch and Burkhead 1981).

I further restrict both prison and comparison group samples to children who have contact with their mothers prior to her entry to jail or prison for the following reasons: (1) the nature of the child-mother relationship is expected to be a crucial factor in understanding the impact of maternal incarceration (Parke and Clarke-Stewart 2001); (2) the existence and nature of the child-mother relationship is a factor that judges or criminal justice policymakers observe at the determination of incarceration; and (3) prior research suggests that the strength of the relationship may predict the magnitude of the impact (T. E. Hanlon *et al.* 2005).[9] Annual data on student guardianship, available in the Chicago Public School (CPS) files from 1994 to 2002, is used as a measure for the mother-child contact level prior to incarceration.[10]

8. Mothers of children in the comparison group only enter jail once, and not prison, during the sampling period. Mothers of children in the prison group will most likely have also spent time in local jail prior to their prison entry. Roughly 57 percent of women in the Illinois Department of Corrections are from Cook County. The prison group mothers' jail spells have been tacked onto their prison spells in estimating the "prison effect," so long as such information was not missing.

9. According to Hanlon *et al.* (2005), children of incarcerated drug addict mothers were neither especially deviant nor maladjusted mainly because in most cases the imprisoned mothers were not the primary caregivers of the children.

10. Information on the legal guardian of a child is first created at the point of registration into the CPS system. The guardian is the person on the child's birth certificate. The record is later updated if there is any change made to the status of the legal guardian and if the child is still attending a school within the CPS system.

A child is included in the analysis as long as he or she has at least one year of maternal guardianship prior to the mother's prison or jail entry. As a result, about 70 percent of children in the prison group and about 86 percent of children in the comparison group are included in the final sample.[11]

IV. Data

A. Characteristics of Sample—Children and Mothers

I observe 2,173 children in the prison group and 4,689 children in the comparison group. In Table 1, I present demographic characteristics of children in these two groups as well as of all children in the CPS system during the academic year 2000. According to estimates in Columns 1 and 2, despite differences in the proportion of mothers with a high school diploma, children in the prison group display many similarities to children in the comparison group. Children from both groups are likely to come from low-income households receiving free or reduced-price lunches and suffer from behavioral disabilities. In addition, the children's ethnic backgrounds are disproportionately African-American. Only a few children from each group are enrolled in bilingual education programs, suggesting that any findings of low test scores are less likely related to any limitations in English proficiency.[12]

However, the difference in demographic characteristics is much more pronounced when comparing the sample children (both prison and comparison groups) in Columns 1 and 2 to all children enrolled in CPS during the academic year 2000 in Column 3. The summary statistics confirm that children in both prison and comparison groups come from one of the most socioeconomically disadvantaged groups in the CPS system, which by itself places them at risk for negative outcomes in terms of academic performance. For instance, compared to the overall education level of mothers with children in CPS, children in both prison and comparison groups have mothers who are much less likely to be high school graduates. Also, they are more disadvantaged in terms of household income, behavioral disabilities, and coming from ethnic minorities. This suggests that a measure of the impact of maternal imprisonment against a comparison group representative of the overall average CPS child would be inherently overstated, if not misleading.

Next, in Table 2, I provide summary statistics on the incarcerated mothers themselves. Information on the mothers' characteristics is fixed during the entire sampling period for each child since such information is collected at the initial time of her prison or jail entry. As observed, children in both prison and comparison groups experience maternal incarceration, on average, around the age of 11 to 12, when the

11. It is not surprising that children in the prison group are less likely to be under the care of their mothers than children in the comparison group. In fact, Hanlon *et al.* (2005) found that about 66 percent of children with imprisoned drug addict mothers reported the grandmother to be the female serving as the mother figure for the longest period of time in their lives.

12. To consider the variance of certain variables across time, specifically, the proportion of children receiving free or reduced-price lunches, enrollment in bilingual education programs, exclusion from test reporting, and learning disabilities, I count the fraction of children who are observed to possess such traits for at least one year during the entire observed sampling period. When compared to the characteristics of the sample children enrolled in CPS for the year 2000 alone, I do not find significant difference.

Table 1
Background Characteristics of Prison Group, Comparison Group, and All Children in Chicago Public Schools (CPS)

	Sample Children		
	Prison Group	Comparison Group	All Children in Chicago Public Elementary School
Number of children	2,173	4,689	289,904
Race (percent)			
White	1.52	3.46	9.34
African American	92.73	86.45	52.49
Hispanic	5.57	9.83	34.67
Other	0.18	0.26	3.50
Male (percent)	50.35	49.86	51.01
Fraction with high school graduate mothers	0.280	0.577	0.722[a]
Fraction of children receiving free or reduced lunch	0.985	0.977	0.866
Fraction of children enrolled in bilingual education programs	0.002	0.007	0.207
Fraction of children excluded from test score reporting	0.178	0.186	0.196
Disability[b] (percent)			
No disability	80.93	80.87	87.49
Physical disability	0.15	0.25	0.97
Emotional/behavioral/learning disability	18.91	18.87	11.54

Note: I have a total of 1,261 mothers in the prison group and 2,591 mothers in the comparison group. All elementary school children in the CPS represent students enrolled in the CPS during academic year 2000 between Grades 1 and 8.
a. This estimate represents the fraction of female adults (age 25 or older) in Chicago that have graduated from high school or obtained the GED in year 2000.
b. I divide disability into two categories—either physical or emotional/behavioral/learning-related disabilities. ''Physical'' disability includes autistic, hearing impaired, other health impaired, physically handicapped, and traumatic brain injury. ''Emotional/behavioral/learning'' disability includes handicapped under section 504, emotional or behavioral disorder, educable mentally handicapped, learning disability, speech/language disabled, and trainable mentally handicapped. When children have both types of disabilities, I code them as emotional/behavioral/learning disabled.

mother is about 33 years old. Each has, on average, slightly more than three kids and is more likely to be incarcerated for drug-related crimes and less likely to be

Table 2
Summary Statistics on Maternal Incarceration

	Prison Group	Comparison Group
Number of children	2,173	4,689
Child's age at mother's index prison or jail entry	11.58 (4.76)[a]	11.10 (4.97)
Mother's age at index prison or jail entry	33.59 (5.91)	32.76 (7.16)
Mother's total number of children	3.30 (1.77)	3.18 (1.90)
Average number of days mother spent in index prison or jail spell	363.1 (411.7)	1.15 (0.90)
Percentile distribution of number of days spent in index prison or jail spell		
5th percentile	61	0
25th percentile	98	1
50th percentile	231	1
75th percentile	456	2
95th percentile	1,156	3
Mother's average number of prison admissions	1.43 (0.73)	0
Fraction of mothers imprisoned once during sampling period	0.69	1.00
Mother's offense type for index prison/jail spell (percent)		
Person crime	11.46	23.33
Property crime	17.12	20.81
Drug crime	59.04	32.12
Sex crime	0.64	3.28
Other	0.87	10.86
Missing	10.86	9.60

Note: Information on mothers is based on administrative records from either CCJ or IDOC. For mothers in the prison group, I only report information on the first prison spell observed during the sampling period referred to as the index prison incarceration. Since the unit of analysis is the child, mothers with two or more children in the sample will be counted multiple times.
a. Standard deviations are in parentheses.

committed for person- or sex-related crimes. Finally, whereas the comparison group consists of mothers who go to jail one time for three days or fewer, a majority of mothers in the prison group (69 percent) enter prison once during the sampling period and stay imprisoned for an average of 363 days. The median number of days spent in prison is only 231 days, roughly seven-and-a-half months. This means that maternal incarceration in prison is also generally a one-time, relatively short-term event. Thus, I specify a model that will be able to identify differential effects of maternal prison incarceration by years before and after the mother's prison entry.

B. Academic Performances of Children

The Iowa Tests of Basic Skills (ITBS) is the official measure of student achievement in Chicago, intended to measure how well students perform in comparison to a national sample of students who take the same test. It is a standardized multiple-choice testing system composed of multiple forms and levels developed at different points in time. I do not include the first and second grade test scores in the following analyses because CPS only requires it for students between the third and eighth grades. I observe the May ITBS reading and math test scores from academic years 1991 to 2002.

The CPS changed their score reporting method on the ITBS exam in 1997 from the grade equivalent metric to the standard score metric. To account for this discontinuity in test score reporting, I approximate the calculation of the children's test scores—the post-1997 ''standard scores''—using information based on the students' raw test scores, test levels, and test formats. From this approximation, I predict test scores for all years in the sampling period, including the post-1997 years for which ''standard scores'' have been reported. I use these recreated scores as the main outcome variable in the following analyses. For further detail on how I recreate the test scores, see Appendix, Section 2.

In Figure 1, I provide the average reading and math test scores of children in the prison and comparison groups as well as of all students who took the test in 2000 who are enrolled in a Chicago public elementary school between Grades 3 and 8. Compared to the average performing Chicago public elementary school student, children in the sample (both prison and comparison groups) have significantly lower test scores across all grade levels, especially in math. For reading, children in the sample perform roughly 15 to 23 points below the average performing student in the CPS, while for math the gap increases to about a difference of 15 to 26 points. This translates into a difference of approximately one to two years of learning. This gap widens for children in upper grades, especially for math test scores, where the average score of the sample eighth grader is lower than the average score of the CPS sixth grader. Despite these low test scores, the difference between test scores of children in the prison and comparison group is not as pronounced—the comparison group's average test score is about one to three points higher than the prison group's average test score across all grade levels. These differences only comprise about 0.07 to 0.13 of one standard deviation.[13]

13. The standard deviation of test scores by grade level are as follows (Standard Deviation of Reading, Standard Deviation of Math, Grade): (15.5, 14.8, third grade); (18.7, 18.5, fourth grade); (21.3, 21, fifth grade); (22.6, 21.6, sixth grade); (25.8, 23.2, seventh grade); and (29.2, 25.2, eighth grade).

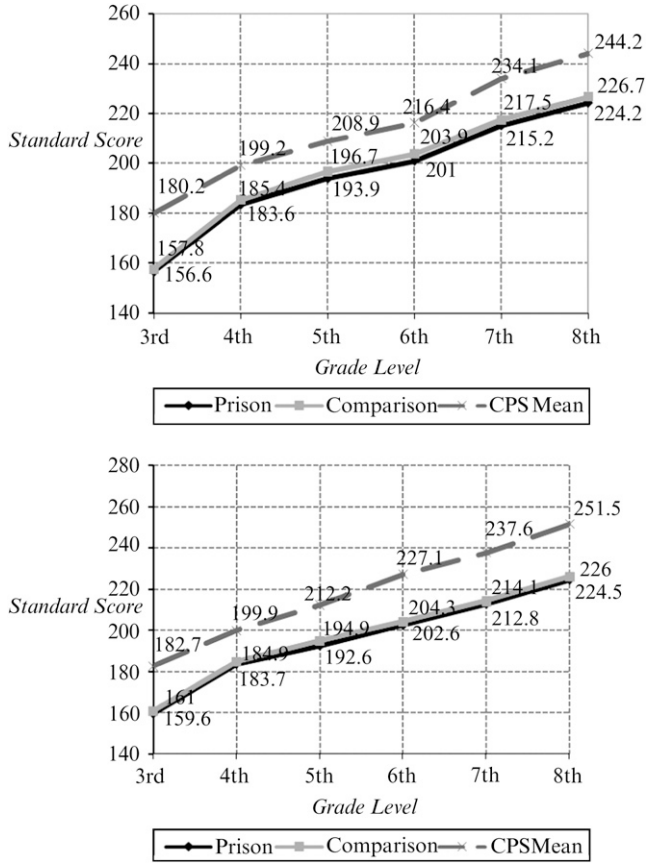

Figure 1

Average Reading and Math ITBS Score by Grade Level

Note: The CPS mean is calculated for all students enrolled in the CPS during academic year 2000 between Grades 3 and 8.

To better understand how test scores of the sample children change relative to the timing of maternal incarceration, I present the temporal pattern in reading and math scores during the years prior to, during, and after the mother's prison or jail entry for each grade level in Figure 2. According to estimates in Figure 2, it appears as if children in the comparison group generally perform better than children in the prison group on both reading and math tests during all periods including years prior to and after maternal incarceration. The gap in test scores between the two groups is larger for children in upper grade levels, as suggested by Figure 1, but there is no apparent increase (or decrease) in the gap relative to the timing of the mother's prison or jail entry. Furthermore, given that the within group variation of test scores

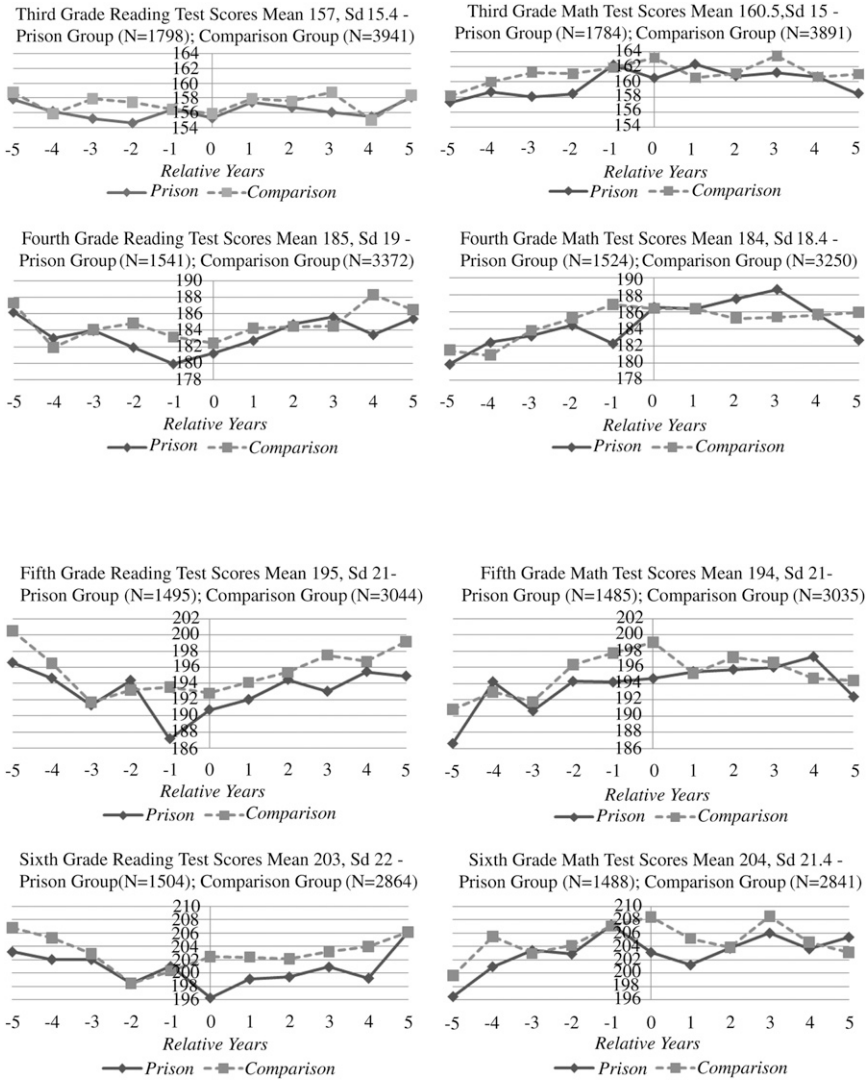

Figure 2

Reading and Math ITBS Test Scores Relative to Mother's Prison or Jail Entry by Grade Level

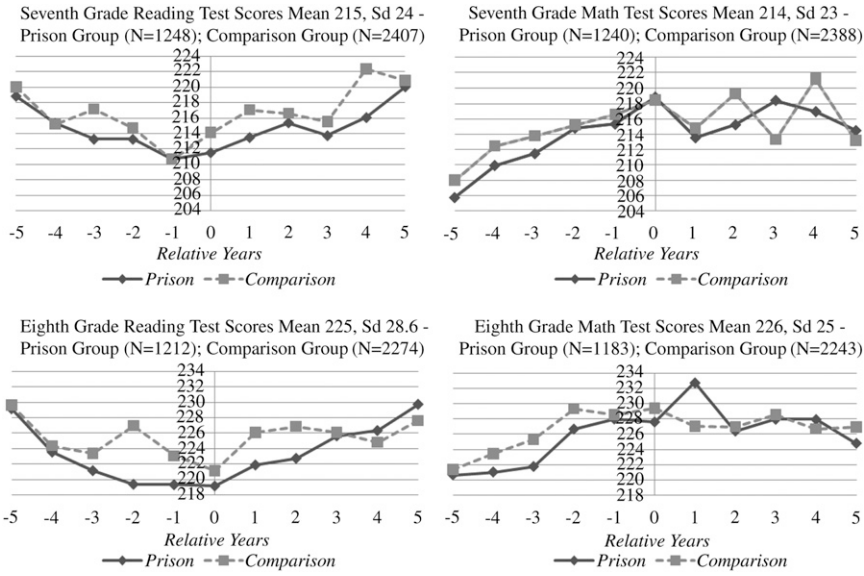

Figure 2 (*continued*)
Reading and Math ITBS Test Scores Relative to Mother's Prison or Jail Entry by Grade Level

also increases with grade level, it is difficult to make any conclusion about the differential change in test scores relative to the timing of maternal incarceration between the two groups. In the next section, I further examine the impact of maternal imprisonment accounting for heterogeneity in unobserved characteristics as well as observed characteristics.

V. Statistical Model

I specify a statistical model that represents children's test score histories and identifies the maternal prison effect with a subset of the model's parameters. In order to allow estimates to vary across both time and individual characteristics, I pool information from children enrolled in Chicago public elementary school between academic years 1991 and 2002 with mothers who enter prison or jail between January 1, 1993 and June 30, 2001. I introduce a series of dummy variables for the number of years before and after the mother enters prison (for the prison group) or jail (for the comparison group). I assume that a child whose mother enters prison (or jail) in 1995 was in much the same position in 1996 as a child whose mother enters prison (or jail) in 1997 was in 1998.[14] The maternal prison

14. I assume that the error process for each individual child is stationary. This implies that the spurious effects of maternal incarceration are symmetric about the date of prison or jail entry.

effect is identified as the difference in the change between prison and comparison group children's test scores relative to their mother's prison or jail entry. In order to control for any differences in the timing of incarceration in prison due to external reasons such as inefficiencies in the criminal justice system, the prison spell is constructed to begin with the preceding jail spell.[15]

I assume that children's test scores at a given year depend on the mother's prison or jail entry through a set of relative year dummy variables and on some controls for fixed and time-varying characteristics. I estimate the following education production function:

$$(1)\quad TestScore_{it} = X_{it}\beta + \theta_k \, RelativeYear_{it}^{k} + \pi \, Prison_i + \delta_k \, Prison_i * RelativeYear_{it}^{k} + \eta_t + \varepsilon_{it} \ ,$$

where i = 1,2,…,9099; t = 1991, 1992,…,2002; k = -3 or less, -2, -1, 0, 1, 2, 3 or more

In Equation 1, the dummy variables, $RelativeYear_{it}^{k}$, where k = -3 or less, -2, -1, 0, 1, 2, 3 or more, represent the relative timing of maternal prison or jail entry (Jacobson, Lalonde, and Sullivan 1993).[16] $RelativeYear_{it}^{k} = 1$ if child i's mother entered prison or jail k years earlier in period t. If k is negative, this means that child i's mother entered prison or jail k years later and if k is zero, this means that child i's mother entered prison or jail in year t.

I assume that maternal imprisonment will not have any direct effect on children's test scores during the three or more years preceding the mother's prison or jail entry. In other words, I force the gap in test scores between prison and comparison group children to be constant (π) during the period three or more years prior to maternal incarceration.[17] These restrictions are sufficient to identify the effects of maternal imprisonment as specified in Model 1.

The term $Prison_i$ in Equation 1 indicates whether the child has a mother entering prison ($Prison_i = 1$) or jail ($Prison_i = 0$), while the coefficient π represents the average difference between test scores of these two groups three or more years prior to maternal incarceration.[18] The term δ_k denotes the effect of maternal imprisonment. It captures the relative difference between the test scores of children in the prison and comparison group k years earlier or after the mother enters prison. The term θ_k denotes the impact of maternal incarceration in jail for comparison group children k years earlier or after the mother enters jail. For a more parsimonious representation of change in test scores across time and children, I assume that the effect of maternal incarceration is constant in the long term. Specifically, I assume that maternal incarceration does not affect children's test scores differently for the three or more years following the mother's prison or jail admission. Finally, to account for the possibility

15. Although using information on arrest, dismissal of charges, or pre-release would be very helpful, it is not available in the prison or jail administrative files of the IDOC.

16. I also try examining maternal prison effects defining the variable $RelativeYear_{it}^{k}$ as relative years before the mother's entry and after her exit of prison or jail. In this case, if k is positive (or negative), this means that child i's mother exited (or entered) prison k years later (or earlier). However, results from the estimation do not change for either specification.

17. In terms of the notation above, I set $\theta\ldots = \theta_{-5} = \theta_{-4} = \theta_{-3} = 0$ and $\delta\ldots = \text{delta};_{-5} = \delta_{-4} = \delta_{-3} = 0$.

18. I have tried estimating the maternal prison effect without this variable, $\pi \, Prison_i$, forcing the test scores between the two groups to be identical during all years preceding maternal incarceration in prison or jail. This does not make much difference to the impact estimates.

of transitory effects,[19] I allow separate effects during the two years preceding the mother's prison or jail entry. This way I am estimating the change in test scores relative to three or more years prior to the mother's prison entry.

The variable $TestScore_{it}$ represents the predicted standard score of the ith child in year t. The vector X_{it} includes individual-specific regressors. The time-varying variables in X_{it} include age, age-squared, test format, and aggregate school quality variables. The fixed observed characteristics include both the child's characteristics—race, gender—and the mother's characteristics—age at first incarceration, high school graduation status, offense type, and total number of kids.[20]

I do not control for grade level or test level since they may be endogenous to maternal imprisonment. That is, a child may be in a certain grade due to grade retention, which is in large part determined by children's test scores and also possibly by maternal incarceration. Also, the test levels of children are determined by grade level as well as other factors that are endogenous to maternal imprisonment. In practice, students are frequently tested ''off level'' by teacher discretion, where a teacher could give a lower level test to a very disadvantaged student or an upper level test to a gifted one. Another endogenous variable that is not included in the model is the mother's length of prison stay. Factors that influence the length of a mother's prison stay such as the severity or frequency of her crime would most likely influence her imprisonment as well.

The term η_t denotes the 12 academic year dummy variables in the sampling period. They capture the general time pattern of test scores as well as changes in policies that may impact students' academic performances. Finally, the term ε_{it} denotes the unobserved characteristics. I first estimate model (1) assuming that the error term, ε_{it}, is orthogonal to maternal imprisonment. The standard error estimates are robust standard errors clustered at the child level.

I reestimate Model 1 considering the possibility that children's unobserved fixed characteristics may be correlated with maternal imprisonment. The OLS estimates will be negatively biased if, for example, mothers in the prison and comparison groups place different values on school work. I define the error term ε_{it} as $\varepsilon_{it} = b_i + \nu_{it}$, where b_i is an individual-specific error component that captures unobserved fixed characteristics of the child. To account for any remaining correlation between children who have the same mother, I estimate an individual fixed effect model at the child level with standard errors that accommodate heteroskedasticity clustered at the mother level. Finally, the variable ν_{it} is assumed to be independently distributed and stationary conditional on observed characteristics. In this particular model, no biases arise if the mother's imprisonment is determined only on the basis of variables included in vector X_{it} and any time-invariant characteristic of the child.

19. If children experience a drop in test scores during the immediate years prior to the mother's prison entry, comparing post-prison test scores to test scores during this period may bias the true impact estimate. This is because the drop may be a temporary shock due to external circumstances of which children would recover from regardless of whether the mother enters prison or not.

20. I mean—center the following variables: child's age, the school-quality measures (average test scores and the percent of students above the national norm), and the age of the mother at prison or jail entry.

Table 3
Effects of Maternal Imprisonment on Children Who Have Contact with Their Mother's Prior to Incarceration

	Reading		Math	
	(1) OLS	(2) FE	(3) OLS	(4) FE
Difference in test scores between prison and comparison group (π)				
Prison group	0.601		0.697	
	(0.855)		(0.831)	
Effect of mother's jail entry (θ_k)				
Difference in pre- and post-jail test scores				
Pre-2 years of jail entry	−0.643	0.457	−0.858	0.052
(θ_{-2})	(0.737)	(0.503)	(0.656)	(0.408)
Pre-1 year of jail entry	−1.116	0.440	−1.380	0.178
(θ_{-1})	(0.810)	(0.609)	(0.758)	(0.497)
Year of jail entry	−1.892*	−0.165	−0.843	0.511
(θ_{0})	(0.943)	(0.709)	(0.892)	(0.606)
Post-1 year of jail entry	−1.434	−0.031	−0.813	0.578
(θ_{1})	(1.092)	(0.852)	(1.012)	(0.699)
Post-2 years of jail entry	−1.376	−0.174	−0.243	0.567
(θ_{2})	(1.264)	(1.009)	(1.123)	(0.813)
Post-3^{+} years of jail entry	−1.061	−0.513	−0.156	0.264
(θ_{3+})	(1.493)	(1.179)	(1.235)	(0.969)
Effect of mother's prison entry (δ_k):				
Difference in pre- and post-prison test scores relative to pre- and post-jail test scores				
Pre-2years of prison entry	0.682	0.111	0.625	0.094
(δ_{-2})	(0.855)	(0.759)	(0.928)	(0.625)
Pre-1year of prison entry	0.595	−0.465	0.822	−0.268
(δ_{-1})	(1.051)	(0.840)	(1.020)	(0.735)
Year of prison entry	0.494	−0.628	−0.077	−0.889
(δ_0)	(1.095)	(0.934)	(1.087)	(0.808)
Post-1year of prison entry	0.496	−0.916	0.504	−0.820
(δ_1)	(1.175)	(1.062)	(1.135)	(0.888)
Post-2year of prison entry	−0.011	−1.461	−0.955	−1.469
(δ_2)	(1.294)	(1.268)	(1.206)	(0.975)
Post-3^{+}year of prison entry	0.285	−0.971	−0.212	−0.483
(δ_{3+})	(1.27)	(1.312)	(1.176)	(1.058)

(*continued*)

Table 3 (*continued*)

	Reading		Math	
	(1) OLS	(2) FE	(3) OLS	(4) FE
Joint significance test				
(H_0: δ_{-2}=0, δ_{-1}=0, δ_0=0, δ_1=0, δ_2=0, δ_{3+}=0)				
F statistic	0.13	0.30	0.71	0.76
Prob>*F*	0.99	0.94	0.64	0.60
(H_0: δ_0=0, δ_1=0, δ_2=0, δ_{3+}=0)				
F statistic	0.11	0.35	0.79	0.90
Prob>*F*	0.98	0.84	0.53	0.46
Number of observations	24,305	26,134	24,077	25,896

Note: Robust standard errors are in parentheses. A *indicates estimated coefficient is significant at the 5 percent level; and **indicates estimated coefficient is significant at the 1 percent level.

The fixed-effect estimates may improve upon the existing literature by controlling for unobserved child effects in an unambiguous manner. However, it is still possible that the internal validity of the estimates could be compromised. For example, if the quality of a mother's parenting skills is related to the child's rate of achievement growth, the estimated effect of maternal imprisonment could be biased. This is because the child-level fixed difference-in-difference estimate would not be able to account for differences in the growth rate of test scores, which may be caused by unobserved mother-level characteristics. I address these concerns after presenting the basic test score results.

VI. Results

The effect of maternal imprisonment is presented in Table 3 through the values of δ_k's. According to Columns 1 and 3 of Table 3, controlling for observed characteristics, children in the prison group with prior maternal contact do not perform worse in reading or math than children in the comparison group with prior maternal contact.[21] This is confirmed by both the size and statistical significance of the coefficients.

The ordinary least squares estimates of the effect of maternal imprisonment in Columns 1 and 3 may be biased, however, if permanent differences between prison and comparison group children are correlated with maternal imprisonment, even

21. I control for children's age, gender, race, grade level at the year of mother's prison or jail entry, mother's offense type, mother's high school graduation status, mother's age at prison or jail entry, mother's total number of kids, and school effects.

Table 4
Effect of Maternal Imprisonment on ITBS Test Scores with Mother-level Fixed Effects

	Reading	Math
Effect of Mother's Prison Entry (δ_k): Difference in Pre- and Post-Prison Test Scores relative to Pre- and Post-Jail Test Scores		
Pre-2 years of prison entry	0.815	0.390
(δ_{-2})	(0.872)	(0.797)
Pre-1 year of prison entry	1.399	1.140
(δ_{-1})	(0.980)	(0.955)
Year of prison entry	1.005	0.221
(δ_0)	(1.085)	(1.080)
Post-1 year of prison entry	0.951	0.462
(δ_1)	(1.219)	(1.189)
Post-2 years of prison entry	0.933	−0.125
(δ_2)	(1.377)	(1.314)
Post-3$^+$ years of prison entry	0.865	0.218
(δ_{3+})	(1.476)	(1.444)
Number of observations	26,082	25,844

Note: Robust standard errors are in parentheses.

after controlling for observed individual characteristics. To address these concerns, I present results after controlling for fixed child-level characteristics in Columns 2 and 4 of Table 3. The interaction terms for all post-incarceration periods—δ_0, δ_1, δ_2, δ_{3+}—become slightly more negative in the child-level fixed effect model.[22] For example, for reading, the impact of maternal imprisonment decreases by about 1 to 1.5 points (0.03 to 0.05 of a standard deviation). The overall size of the coefficients ranges between -0.6 and -1.5 points, roughly between -0.02 and -0.05 standard deviations. Still, none of the post-incarceration coefficients (δ_0, δ_1, δ_2, δ_{3+}) are statistically significant at the 5 percent or even 10 percent level. Coefficients for math test scores are similar both in magnitude and statistical significance. The joint *F* tests of all four (or six) post-incarceration periods for both reading and math are not statistically significant.

Results from the OLS and FD specifications provide a useful indication as to whether a child's unobserved background characteristic is related to their chances of having an imprisoned mother. Given that the impact of maternal imprisonment does not change much as child fixed effects are controlled for, there does not seem to be much difference in unobserved propensity to score higher in standardized tests between the two groups.

22. The results do not change in terms of magnitude and statistical significance when the sample is not restricted to children who have maternal guardianship prior to incarceration. This indicates that children who are not under their mother's care prior to her incarceration are not more (or less) disadvantaged in terms of academic performance subsequent to the mother's prison entry.

VII. Specification Check

The test score results in Table 3 suggest that children do not experience a decline in reading or math test scores following the event of maternal imprisonment, conditional on observed and unobserved child fixed characteristics. However, these results could be misleading if there are unobserved mother characteristics associated with both the child's performance in test scores over time and the mother's incarceration status. For example, children in the prison group may be less likely to suffer from maternal neglect or abuse that causes them to become slower learners than the children in the comparison group because they are more likely to have other relatives involved in their lives who provide them with the necessary emotional and financial support.[23] In this case, the child-level fixed difference-in-difference estimates in Table 3 would be underestimating the true effect. Although it is not possible to address these concerns definitively with the observational data, it is possible to examine the empirical relevance of the possible source of bias.

To examine whether children with mothers in prison are slower learners due to omitted characteristics of the mother that influence a child's achievement, I re-estimate model (1) with a mother fixed effect component. This is possible given that there are many children in both the prison and comparison groups that are siblings.[24] Results from the mother-level fixed-effect estimation, reported in Table 4, should provide information on whether there are unobserved mother characteristics that could potentially bias the estimated effect of maternal imprisonment. That is, the estimated effects of maternal imprisonment between the OLS (Columns 1 and 3 of Table 3) and the mother-level fixed-effects regressions (Columns 1 and 2 of Table 4) should differ if there are unobserved differences between mothers in the prison and comparison groups that influence the growth in children's test scores.[25] According to Table 4, the post-incarceration coefficients for both reading and math slightly increase and become positive. However, as indicated by the size of the standard errors associated with these estimates, the reported estimates are not different from the estimates produced in Columns 1 and 3 of Table 3. The comparative results suggest that there is no evidence that omitted mother level characteristics influence the rate of achievement growth once we control for the observed characteristics of children and their mothers.

VIII. Conclusion

What is the effect of a mother entering prison? The results indicate that children with prior maternal contact do not experience a decrease in reading

23. Research on kinship ties and race suggests that African-American families display stronger kinship networks than white families because of cultural and economic differences (Hays and Mindel 1973; Sigle-Rushton and McLanahan 2002).

24. I have 3,836 and 3,808 unique mothers in either the prison or comparison group associated with 26,082 and 25,844 observations respectively for reading and math.

25. Estimates would be biased only if unobserved mother characteristics affect the growth rate of children's achievement since all differences in the levels of achievement caused by unobserved mother characteristics are already accounted for when controlling for child-level fixed effects.

or math standardized test scores following the event of maternal imprisonment. The change in test scores of children in the prison group are not different from the change in test scores of children in the comparison group after the mother's incarceration when controlling for observed and unobserved fixed characteristics. This suggests that although children with imprisoned mothers have lower test scores than the average child attending public elementary school, they do not appear to perform worse because of their mother's imprisonment.[26]

What are the implications of the findings in terms of public policy? To better understand the magnitude of the economic effects of maternal imprisonment from a broader context, a rough cost-benefit analysis can be performed. The direct cost of incarcerating a woman in Illinois state prison is about $21,622 per year.[27] Since the median woman spends about 7.5 months in prison, it would cost the state government about $13,622 (=.63*$21,622) per marginal female prisoner. On the other hand, there are economic benefits of incarceration either in the form of crime deterrence or reduction. Prior studies suggest that violent crimes have greater benefits than nonviolent crimes (Cohen 1988; Levitt 1996; Lochner and Moretti 2004). However, according to Greenfeld and Snell (1999), only about 8.4 percent of women in state prison are committed for violent crimes, while 43 percent are committed for property crimes and 37 percent for drug crimes. Furthermore, murder and rape/sexual assault crimes, which have the highest social benefits when reduced or deterred, comprise less than 11 percent of the total violent crimes for female inmates and less than 1 percent of all crimes committed by women. Applying a fraction (0.63) of the estimated costs of violent and property crimes reported in Lochner and Moretti (2004), I can estimate the benefit of incarcerating an additional female prisoner to be approximately $12,589.[28]

The above analysis confirms our initial concern that current imprisonment numbers may have exceeded their optimal level when considering the cost-benefit calculus for the marginal prisoner - female inmates who have committed nonviolent crimes. As presented above, despite the absence of loss in their children's academic performance, the benefit of incarcerating a woman with children still does not exceed its costs.[29] This inadequate benefit may be a larger problem considering that there could be other potential costs of incarcerating mothers that are not included in this analysis. For example, the costs are likely to be greater when taking into account the financial and emotional burden imposed on extended family members as they

26. Children in the sample have test scores that are, on average, 0.7 to 1.5 standard deviations below the average child in the CPS.

27. The IDOC estimated the annual cost of incarcerating an adult to be $21,622 in 2005. http://www.idoc.state.il.us/subsections/reports/department_data/Department%20Data%202005.pdf

28. Greenfeld and Snell (1999) report the average out-of-pocket cost of female violence to be about 63 percent of the cost of male violence because females are less likely to use weapons and cause serious physical injuries.

29. If children had experienced a decline in academic performance, the cost of maternal imprisonment would have increased by the amount of loss in future earnings. For example, Murnane *et al.* (1995) report that male high school seniors who score one standard deviation higher in basic math achievement tests earn about 6.88 percent higher earnings six years later, while the equivalent figure for females is about 10.63 percent.

take over the role of the incarcerated primary caregiver, or the increased cost to society through consumed social welfare services relating to foster care.[30]

I end this paper with a note on the limitations in interpreting these results. Because the sample consists of children who are between the third and eighth grades, I am unable to estimate the immediate effects of maternal imprisonment on younger children who are not enrolled in school when their mothers enter prison. This may be an important limitation of the current study, given that research on child development suggests the harm of mother-child separation to be greatest during the critical periods of early childhood (Han, Waldfogel, and Brooks-Gunn 2001). In addition, given that the sample children consist of students attending public elementary school in the city of Chicago, the results of this paper may not be generalizable to children in nonurban areas. The subsequent stigma or shame associated with maternal imprisonment should be correlated with the frequency of imprisonment in the residing community. Lastly, this paper only examines the effect of maternal imprisonment on children's cognitive skills as measured by performance on standardized test scores. It is very much possible that children are still influenced cognitively in forms immeasurable by standardized tests, as well as in terms of other important characteristics including the development of noncognitive skills.

Appendix

1. Sample Construction

Chapin Hall has created a data set based on state-level administrative records tracking the histories of incarcerated women in Illinois and their children as they move through the criminal justice system, foster care, welfare programs, and the legitimate labor market. The individual records in this file come from essentially two sources: the Illinois Department of Human Services (DHS) and Illinois Department of Children and Family (DCFS) services. The DHS records provide information on Food Stamp, AFDC/TANF, and Medicaid spells, while the DCFS records include foster care spells and history of allegations to abuse or neglect covering the period from 1990 through 2001. As a result, the incarcerated female population represented in this analysis consists of incarcerated women, either in jail or prison, who have a public aid record (Food Stamps, AFDC/TANF, or Medicaid) or a child welfare record (foster care or allegation of abuse or neglect) that started between January 1, 1990 and June 30, 2001. Spells that do not end by this date are right-censored and given June 30, 2001 as the end date. The match rate between the Illinois Department of Corrections (IDOC) and IDB files was about 82 percent, and the match rate between Cook County Jail (CCJ) and IDB files was about 56 percent.

I have information on each inmate's date of birth, race, offense type, high school graduation status, total number of kids, and the date of entry and exit for each incarceration spell. In addition, for mothers in the prison group, I have information on

30. About 10 percent of children are placed in foster care after their mothers are incarcerated (Mumola 2000).

marital status, prior substance abuse, and county of admission. I observe all incarceration spells during the sampling period, and can calculate time spent incarcerated for each spell.

School outcome data on children of incarcerated mothers are identified if the mother has records in the IDB database and if the children attend schools within the Chicago Public Schools (CPS).[31] Both the child and mother have a unique Chapin Hall identifier, which was created by using probabilistic matching across all files. Using these identifiers, I am able to match CPS records to the IDB database. The school records consist of mainly three files— the enrollment file, the standardized test score file, and the guardianship file. As a result, I have information on the school each child is attending, the school s/he transfers to if the transfer is made within the CPS, grade retention, and graduation or dropout status. In addition, I have test scores on the Iowa Test of Basic Skills (ITBS) in reading and math from 1991 to 2002. The guardianship file identifies the relationship between the child and his or her guardian for each academic year. It contains guardianship information between academic year 1994 and 2002. I have information on students' basic demographic characteristics such as race, gender, and date of birth. I am also able to identify students' disability, bilingual program enrollment, and reduced-price or free lunch program participation.[32] The test score file also includes information on whether a child is stably enrolled in each academic year of testing and whether s/he was excluded in the reporting of scores to the district or city.[33]

The final sample consists of 2,173 children with 1,261 mothers in the prison group and 4,689 children with 2,591 mothers in the comparison group. As presented below, sample children are more likely to be concentrated in lower grade levels. This is not surprising since the median age of state prison entry is reported to be around 33. The grade-level percentile distributions for children in the prison and comparison groups are as follows: Grade level (prison group percentage; comparison group percentage)— third grade (20.43 percent; 22.12 percent), fourth grade (17.49 percent; 18.37 percent), fifth grade (17.02 percent; 17.11 percent), sixth grade (17.10 percent; 16.09 percent), seventh grade (14.21 percent; 13.54 percent), and eighth grade (13.75 percent; 12.76 percent).

2. Creating Predicted Standard Scores

Until recently, ITBS test scores have been reported in a grade equivalent (GE) metric that reflects the number of years and months of learning. For example, since the exam is given in the eighth month of an academic year (May), a third grader at the 50th percentile in the nation scores 3.8 GE. In 1997, the reporting system changed to report scores using the GE metric as well as a new scoring metric called the

31. I do not have access to school records of children who are not in school, who are not in Chicago, or, if they are Chicago children, who do not go to a Chicago Public School (CPS).
32. Information on disability and free lunch status or reduced lunch status is provided only for years from 1997 to 2002. Bilingual program participation is only identified only for years between 2000 and 2002.
33. A child is considered stably enrolled if he or she is enrolled before October 1 of each academic year. This variable is coded from 1995 to 2002.

Standard Scores (SS).[34] This new scale was introduced mainly because of GE's incomparability across children in different grade levels.[35] The Standard Score is a number that describes a student's location on an achievement continuum. It assigns different scores to the national 50th percentile student for each grade, for example, 200 to the median performing student in fourth grade and 250 to eighth grade.[36] The scale also adjusts for the fact that annual growth in test scores decreases as students move up from one grade to the next. The new metric, therefore, makes it possible to compare a first grader's achievement to that of a fourth grader's.

Yet, there are still several reasons why the new metric, the Standard Score, is inappropriate as the outcome variable in measuring changes in student achievement. First, different test forms of the exam are administered each year.[37] This may cause one to confound changes in test performance over time with changes in the difficulty of test formats. Second, the skills assessed by the ITBS have changed over the 10 year time period. Bryk *et al.* (1997) find that since the early 1990s the test has been changing to reflect recent emphasis on introducing more challenging mathematics into elementary schools.[38] As a result, the reported scores are sensitive not only to grade level and test form, but also to the academic year in which the test was taken. Finally, the Standard Score is not reported for years prior to 1997. Only the raw test scores and grade equivalents (GE) were provided for years between 1991 and 1996.

To solve these problems, I create a new metric called the ''predicted'' Standard Scores and use it as the outcome variable. The predicted Standard Score is obtained by fitting an Ordinary Least Squares (OLS) model to the logarithm of the Standard Scores (SS)—for both reading and math separately—from 1997 to 2002 on the mean-centered raw scores and its polynomials of degree two, three, and four, controlling for different test levels and years.[39] Basically, I approximate the computation of

34. The CPS stopped using the GE in 2002 and replaced them with Standard Scores. However, both measures were reported between 1997 and 2001.

35. The GE is not a linear metric. This means that a score of 4.3 on Level 11 of the exam does not represent the same thing as a score of 4.3 at Level 12. Thus, it is difficult to accurately compare the ability of two students if they are in different grades.

36. The median performance of students in each grade level is presented below.

Grade	1	2	3	4	5	6	7	8
SS	150	168	185	200	214	227	239	250

37. Three different series of test forms were given each spring (May) of 1990 and 2004. From 1990 to 1992, G-H-J series were provided, from 1993 to 2001, K-L-M series were provided, and from 2002 to 2004, A-B series were provided.

38. Bryk *et al.* (1998) performed a content analysis on the ITBS through the periods between 1990 and 1996. They found a major content shift occurring in the test series beginning in 1993. A whole new content area on ''data related concepts'' appeared while there was a major increase in ''equation'' problems across all grades.

39. I have tried running the OLS model with the raw SS on the covariates as well. However, the R-squared statistics decrease to about 0.94. This is because the raw SS has a concave distribution with respect to grade level by construction, and thus applying the logarithm function to the SS fits the data better. I include the ''demeaned'' reading and math raw scores and its polynomials instead of the original raw scores in order to prevent the approximation equation from becoming unstable.

Standard Scores based on the last six years (from 1997 to 2002) of the test, and then predict the scores for all years from 1991 to 2002.[40] I control for differences in test forms using dummy variables for each year. I adjust the coefficients of each year dummy variable to zero before making any predictions since I do not observe any pre-1997 Standard Scores. This will prevent post-1997 year effects from predicting pre-1997 test scores. The reason I do this instead of dropping the year dummies altogether is to control for any differences in the variance of test scores across years. I obtain relatively high R-squared statistics for both reading and math score approximations, ranging between 0.95 and 0.99.[41] Since I have removed any year effects from the predicted Standard Scores, there will be no difference in test scores due to changes in policy across years.

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40. I fit a flexible model to the data by including polynomials of up to degrees of four. This is based on the technique of a standard Taylor series expansion model.

41. The *R*-squared statistic is calculated accounting for the adjustments made to the year dummy variables. It is calculated as one minus the ratio of *R*-squared statistics for a regression controlling for only the year dummy variables and a regression controlling for the raw score and polynomials, test levels, and the year dummy variables.

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