New Estimates on the Effect of Parental Separation on Child Health

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Abstract

This study examines the causal link between parental non-marital relationship dissolution and the health status of young children. Using a representative sample of children all born out of wedlock drawn from the Fragile Families and Child Wellbeing Study, we investigate whether separation between unmarried biological parents has a causal effect on a child's likelihood of developing asthma. Adopting a potential outcome framework to account for selection of relationship dissolution, we find that children whose parents separate within three years after childbirth are seven percent more likely to develop asthma by age three, compared to if their parents had remained romantically involved. We provide evidence that socioeconomically disadvantaged fathers are more likely to see the relationship with their child's mother end, and selection into relationship dissolution along these dimensions helps explain the poorer health outcomes found among out-of-wedlock children whose parents separate.

Keywords: Child Asthma, Fragile Families, Relationship Dissolution, Propensity Score Matching

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1 Introduction

While marriage remains the most common foundation of family life in the U.S., the prominence of the traditional process of family formation, namely marriage before having children, is diminishing. Today, more than one-third of all births in the U.S. occur outside of marriage (Martin et al., 2006). Although most unmarried parents are romantically involved when their child is born (Carlson et al., 2004), many separate before their child reaches age three (Osborne and McLanahan, 2006). While the consequences of *marital* dissolution on children have been studied extensively,[1] the effect of separation of never-married parents on child wellbeing has rarely been examined. This is mainly due to the lack of large representative surveys that collect detailed information on men who father children born out of wedlock.[2] If the characteristics of the parents and their relationship that determine the risk of union dissolution also affect child wellbeing, then estimates of the effect of separation on child outcomes that fail to account for these factors may suffer from confounding or "selection bias".

Even when detailed information on the determinants of child wellbeing is available and can therefore accounted for, however, conventional regression approaches such as Ordinary Least Squares (OLS) may produce invalid estimates of the effect of separation on child wellbeing. Regressions rely on strong functional form assumptions (linearity between the covariates and the outcome of interest). In the present context we expect that children who experienced separation ("treated") may have very different characteristics or environments than children whose parents remained involved ("untreated"). Not only may the treated children differ in terms of the means of their characteristics and environmental variables from the untreated, but also the distribution of these variables could overlap relatively little across groups ("lack of common support"). In this case the regression will project the outcome of the untreated children outside the observed range to form a comparison ("counterfactual outcome") for the treated children at common values of the covariates. The concern is that such projections, which are highly sensitive to functional form assumptions, will be invalid.

[1] See Cherlin (1999) and Liu (2006) for recent surveys of this literature. See Morrison and Ritualo (2000) for evidence on the economic consequences of cohabitation and remarriage for children who experienced parental divorce.

[2] Finding a representative sample of nonresident fathers has proved extraordinarily difficult. In U.S. nationally representative surveys such as the CPS, NSFH, and SIPP, researchers estimated that more than one fifth and perhaps as many as one-half of nonresident fathers are "missing," i.e. not identified as fathers (e.g., Cherlin et al., 1983; Garfinkel et al., 1998; Sorenson, 1997). The problem is especially pronounced for men who fathered children outside of marriage: More than half appear to be missing. Although longitudinal studies of divorced fathers offer a more complete picture, even these suffer from non-inclusion and non-response bias (Garfinkel et al., 1998).

To measure the effect of relationship dissolution on child wellbeing, ideally researchers would use data from randomized experiments or controlled social experiments where parental separation (the treatment) was randomly assigned. In the absence of such data, one strategy is to only compare outcomes between children who experienced parental separation and otherwise similar children whose parents remained together, thereby minimizing potential bias from confounding factors. The challenge of this matching strategy in practice is to identify those children in the untreated group who can serve as good comparisons to the children in the treatment group, i.e. to balance out the children being compared in terms of their characteristics and environmental factors. This approach makes extensive use of the observed characteristics, provides a direct test of whether the observables have common support, and is non-parametric as it does not require assumptions regarding the functional form of the relationship between characteristics and child outcomes.

This study employs a matching strategy to identify whether union dissolution between unmarried parents (defined as the dissolution of a romantic relationship) has a causal effect on child health. We focus on the effect of parental relationship dissolution within three years since childbirth on the child's likelihood of developing asthma by age three.[3] The analysis utilizes data from the Fragile Families and Child Wellbeing Study (FFCWS), which provides detailed information on both biological parents of a large sample of children born out of wedlock. The FFCWS allows us to estimate the separation effect accounting for an unusually large set of characteristics of the child's parents and their relationship. We present estimates from standard parametric regressions as well as a semi-nonparametric approach based on propensity score matching (Rubin, 1979; Rosenbaum and Rubin, 1983; Heckman and Hotz, 1989; Heckman et al., 1997, 1998). The latter method matches each child whose parents separated with children whose parents remained romantically involved but share similar (observable) characteristics, then compare the outcomes of these matches. By only using those children that are very similar to children of separated parents to estimate the counterfactual child outcome, the matching method helps us identify the causal relationship between separation and child health. We find that parental separation increases a child's odds of developing asthma by age three by $6\% \sim 7\%$, relative to the situation where

[3]Much of the existing evidence on the effects of family structure and child outcome stems from studies using data on the wellbeing of school-age children and adolescents. We focus on early child outcomes since unmarried families tend to be less stable and hence more short-lived (Bumpass and Lu, 2000; Manning et al., 2004), findings from these previous studies may be characteristic of stable unmarried families only.

their parents *had remained romantically involved*.

2 Background

This section provides the conceptual and empirical background for analyzing the effects of separation on child wellbeing, with special emphasis on how separation of the biological parents may harm children born out of wedlock. We draw on the literatures on family formation, dissolution, and resource allocation (e.g., Becker, 1973, 1974; Becker et al., 1977; Weiss and Willis, 1997; Willis, 1999; Ribar, 2006), which stress the importance of family resources (time and money) and endowments (caregivers' ability) in the production of family public goods such as child health ("child quality").

Consequences of Separation

Parental separation is expected to lead to a reduction in parental involvement with and resources for the children as benefits associated with growing up in a (parental) union are at best temporarily interrupted and potentially discontinued for a prolonged amount of time.[4] McLanahan (1985) shows that income explains up to half of the differences in child wellbeing between one- and two-parent families. Unions yield gains from specialization and exchange in the presence of comparative advantages of the partners. Couples may also pool individuals' resources, and realize economies of scale in household production and gains from exploiting risk-sharing opportunities.[5] Individuals may also be more productive as part of a family due to social learning or other positive externalities.[6] Lastly, the effective use of monetary transfers from one partner to the other on behalf of the child is more easily monitored within a union (Willis and Haaga, 1996; Willis, 1999).

[4]For a detailed discussion of the benefits of a parental union, see Becker (1991); Michael (1973); Shaw (1987); Drewianka (2004).

[5]Following Becker (1991), the pooling of all resources arises if the dominant decision-maker is altruistic or if the partners have the same objectives. However, if these assumptions are relaxed (McElroy, 1990; Manser and Brown, 1980; McElroy and Horney, 1981), one person's resources cannot be treated as common household income.

[6]Waite and Gallagher (2000) find some evidence that living together may induce a stabilizing effect on the partners, which can increase resources as a result of greater productivity at home and in the labor market.

Existing Evidence

Parents' economic resources have been shown to be important determinants of child wellbeing (Blau, 1999). While caregivers' time and income are substitutable to a certain extent as money can buy child-care services and working in the labor market increases available financial resources, both time and material resources are needed for healthy child development (Coleman, 1988). Especially, parenting resources—the services provided by the parents using their time and childrearing ability are believed to be important complements to economics resources (McLanahan and Sandefur, 1994).[7] Studies that compare children across living arrangements have shown that children in single-parent families experience fewer economic and parenting resources (Brown, 2002; Hofferth, 2001). Single parents may be unable to perform the multiple roles and tasks required for childrearing, which can result in heightened stress levels and insufficient monitoring, demands, and warmth in their parenting practices (Cherlin, 1992; Thomson et al., 1994; Wu, 1996). Conflicts over visitation may also encumber parenting effectiveness (Brown, 2004).

While a large body of research consistently shows a negative correlation between marital dissolution and child outcomes,[8] until very recently, the relationship between non-marital separation and child wellbeing has received little attention. Heiland and Liu (2006) report that children born to cohabiting or visiting (i.e. romantically involved but living apart) biological parents who end their relationship within a year after birth are up to 9% more likely to have asthma compared to children whose parents stayed together. They also report an increase in child behavioral problems associated with a break-up among children born to romantically involved but not co-residing parents but no effect on mother-reported child health status measures. However, their estimates are obtained from conventional (parametric) models and whether these correlations reflect causal relationships is unclear.

Separation and Selection

A change in the parental relationship towards no (romantic) involvement is expected to decrease the availability of resources and paternal investments in children. However, the environment provided

[7]For example, parental interaction with the child has been found to foster the development of the child by providing support, stimulation, and control (e.g., Maccoby and Martin, 1983).

[8]See Ribar (2006) and Liu and Heiland (2007) for recent surveys of the literature on the effect of marriage on child wellbeing.

by and the characteristics of parents who separate may differ substantially from parents who remain together. In examining the effect of separation on child outcomes, potential differences in the characteristics of the parents who break up and those who stay together, need to be addressed.

Economic theories of relationship dissolution posit that couples break up when the value of the 'outside opportunity' of one partner exceeds the benefits from continuing the relationship (Becker et al., 1977; Weiss and Willis, 1997). This implies that dissolution does not occur randomly across couples which complicates the identification of the effect of separation on child wellbeing. Simple comparisons of child outcomes by parental relationship status can be misleading if, for example, couples with characteristics that benefit child health are also more likely to break up after childbearing (ceasing a source of positive influence), compared to those who remain together, then the (negative) consequences of separation may be understated (e.g., Steele et al., 2007; Liu, 2006). Conversely, if arrangements that induce adverse effects on the child—such as having an abusive father—are more likely to end in a break-up, the association between separation and child wellbeing may even become positive (e.g., Jekielek, 1998).

The benefits of father involvement in childrearing are increasingly recognized (see e.g., Lamb, 2004). The father's involvement in the child's life may depend on the quality of his relationship with the mother. Couples in good relationships tend to communicate more effectively and mothers are more likely to encourage the father's active involvement in both her and the child's lives (Carlson et al., 2004). In contrast, when mothers are not able to cooperate with the father and do not perceive that he has the child's best interests at heart (or are unable to provide for her and their children), they may discourage his involvement and end the romantic relationship. Sigle-Rushton (2005) found that men who fathered children outside of marriage are more likely to come from socioeconomically disadvantaged backgrounds and receive public assistance. Separating from a "deadbeat" dad may reduce the mother's stress level and allow her to increase available resources for the child through forming new partnerships (e.g., Waller and Swisher, 2006).[9]

[9] McLanahan and Sandefur (1994) found that children living in stepparent families generally have better outcomes than children in single-parent families.

3 Statistical Framework and Estimation Strategy

Conceptual Model

Consider a (romantically involved) couple i who has a child out of wedlock. Borrowing from the standard formulation of a selection problem in econometrics, the interrelation of child outcomes, parental investments in children, and relationship status may be formalized as follows:

$$C_i = \beta S_i + \gamma X_i + \varepsilon_i \tag{1}$$

$$S_i = \delta X_i + \nu_i \tag{2}$$

where C_i denotes the observed child outcome of couple i. S_i is equal to 1 if the couple separates (i.e., dissolve their romantic relationship) and 0 otherwise. The vector X_i includes characteristics of the couple i that affect its willingness and ability to make child investments as well as the risk of relationship dissolution. Unobservables affecting child wellbeing and parental separation are captured by ε_i and ν_i, respectively.

Regression approaches seek to identify the effect of union dissolution on the wellbeing of children, β. Estimates of β based on standard regression methods such as Ordinary Least Squares (OLS) may be biased if S_i and ε_i are statistically dependent. This dependence can arise from two sources: First, couples characteristics (child investments) may be correlated with unmeasured health endowments, i.e. X_i and ε_i are correlated. There may also be bias due to unobservable factors that affect both the child outcomes and the couple's relationship status. In either case, at least part of the observed relationship between child outcomes and the indicator for parental separation is spurious (confounded). The existence of either source of bias would likely cause children of separated parents to have different outcomes from their peers whose parents remained together, independent of any true causal effect of parental separation on child outcomes (selection bias problem).

Selection bias arise in conventional regression analysis as these estimators employ data from all observations to be combined into one estimate of the separation effect. If parents who remain together tend to be very different regarding their child investments compared to couples who separate, then the validity of results from standard regression models is suspect since the combining functions operate over very different families. Specifically, the separation effect is identified by comparing the average outcome of children who experienced a dissolution to those who did not. In the presence of any characteristics that affect the couples' decision to separate as well as child wellbeing, the resulting estimates will reflect both the "true" effect of parental separation on children who experience union dissolution *and* the effects of factors that influence the parents' risk of separation in the first place.

In addition to estimates from conventional regression approaches, this study builds on a non-parametric strategy known as the potential outcome approach to investigate the effect of parental separation on child health. In this approach, the relationship between union dissolution and child outcome is formulated in a framework similar to a social experiment in which the treatment is randomly assigned. Pioneered in the program evaluation literature in economics (see e.g., Lechner, 2002; Imbens, 2004), the matching approach has been fruitfully employed to study the effect of an event ("treatment") on participant outcomes when participation ("selection into treatment") is expected to be non-random. For instance, when analyzing the effect of a welfare program on individuals, researchers want to know what the outcomes of the participants would have been had they not enroll in the program. Since data on the counterfactual are typically unavailable in observational data, one needs to rely on the behavior of the non-participants in the sample to construct the counterfactual outcome. However, since welfare participation is voluntary, the participation choice is non-random and participants tend to exhibit different characteristics from non-participants. As a result, standard regression estimates of the effect of the treatment, obtained from comparing participants with non-participants who are systematically different, will be confounded with the effects of selection into participation. The matching method is particularly useful in this situation as it re-establishes the conditions of an experiment, by matching the sample of participants and non-participants with respect to characteristics that rule the selection into program participation (treatment).

In the present context, the "treatment" of interest—parental separation—is defined in terms of the potential outcomes for children whose parents separated. Children whose parents separated are in the treated group, and children whose parents remained romantically involved are defined as the control group (or "untreated"). We want to identify the effect of parental separation on children whose parents separated. To construct the counterfactual, i.e. the outcomes of children whose parents separated had their parents remained romantically involved, we draw on matching methods developed in the statistics literature (Rosenbaum and Rubin, 1983; Heckman and Robb, 1985) that exploit the full information of the observable characteristics. Unlike regression approaches, these methods balance out the groups being compared in terms of their covariates and do not require assumptions regarding the functional form of the relationship between characteristics and child outcomes. Specifically, they provide systematic ways to construct a sample counterpart for the missing information on the counterfactual outcomes of the treated children by pairing treated and control children who share similar observable characteristics. Our application of propensity score matching to the study of parental separation on child health is novel and adds to the growing number of areas within population studies that have benefited from this technique (see Sigle-Rushton, 2005, Liu and Heiland, 2007, and the related chapters in this book for additional applications).

We note that the methodology adopted here addresses selection on observable factors and does not readily extend to selection on unobservables. If unobservable factors are proxied for by X_i then matching based on observables also reduces selection bias generated by unobserved factors. The extent to which the treatment bias is reduced will thus crucially depend on the richness and quality of the control variables, X_i, that are used to match treated and control observations. Typically, the information about the parents of out-of-wedlock children and their relationship is limited in large representative survey datasets. Fortunately, the FFCWS contains detailed information on the child as well as both biological parents and their romantic involvement, allowing us to capture factors believed to be important determinants of the separation risk including the degree to which the parents are assortatively matched.[10]

Potential Outcome Approach

Consider the "treatment" to be the separation (i.e. romantic relationship dissolution) between the biological parents of child i: $S_i = 1$ denotes the "treatment group" (i.e. children whose parents separate), and $S_i = 0$ denotes the "control group" (i.e. children whose parents remain romantically involved). Let

[10] Approaches that seek to address selection bias due to unobservables directly include treatment effects estimators and instrumental variables estimators. The former essentially model the selection process directly and require strong distributional assumptions. In the context of divorce and child outcomes, variation in state and local divorce policy and costs have been used as instruments for divorce. However, to what extent these types of events can serve as valid instruments has been debated (see Steele et al., 2007; Liu, 2006) and finding a suitable instrument for union dissolution among unmarried couples promises to be even more challenging.

$C_i(1)$ denote the potential outcome of child i under the treatment state "parents separated" ($S_i = 1$), and $C_i(0)$ the potential outcome if the same child receives no treatment, "parents remained romantically involved" ($S_i = 0$). Thus, $C_i = S_iC_i(1) + (1-S_i)C_i(0)$ is the observed outcome of child i. The individual treatment effect is $\beta_i = C_i(1) - C_i(0)$, which is unobserved since either $C_i(1)$ or $C_i(0)$ is missing.[11]

Ordinary least squares estimates the average treatment effect (ATE) by taking the average outcome difference between the treated and control groups: $\beta_{OLS} = E[C_i(1)|S_i = 1] - E[C_i(0)|S_i = 0]$. The ATE is the average of the treatment effect on the treated *and* the treatment effect on the controls. Given that many children whose parents remained involved may never be at risk of parental separation, the ATE may not be particularly illuminating when our interest lies in how parental separation has affected children whose parents did separate. Hence, alternatively, one might focus on the average effect of treatment on the treated only ("effect of parents' separation on children whose parents separate"), i.e. the ATET henceforth:

$$\beta_{S_i=1} = E[\beta_i|S_i = 1] = E[C_i(1)|S_i = 1] - E[C_i(0)|S_i = 1] \tag{3}$$

which is the difference between the expected outcome of a child whose parents separate, and the expected outcome of the same child if his/er parents had remained romantically involved. While we do observe the outcomes of children whose parents separate, and are thus able to construct the first expectation $E[C_i(1)|S_i = 1]$, we cannot identify the counterfactual expectation $E[C_i(0)|S_i = 1]$ without invoking further assumptions. To overcome this problem, one has to rely on children whose parents remained romantically involved to obtain information on the counterfactual outcome. Since treatment status is likely non-random, replacing $E[C_i(0)|S_i = 1]$ with $E[C_i(0)|S_i = 0]$ is inappropriate since the treated and untreated might differ in their characteristics determining the outcome.

An ideal randomized experiment would solve this problem because random assignment of couples to treatment ensures that potential outcomes are independent of treatment status;[12] and if such data exist, conventional regression methods would produce an unbiased estimate of β. However, this would

[11] The individual treatment effect is equivalent to taking the difference between the outcome of child i if his/er parents separated, and the outcome of the same child if his/er parents remained together. Since for any given child, his/er parents can only be observed as either "separated" or "remained involved", we can never observe the outcomes of a given child in *both* of these situations.

[12] Randomization implies that $S_i \perp (C_i(0), C_i(1))$ and therefore: $\mathrm{E}[C_i(0)|S_i = 1] = \mathrm{E}[C_i(0)|S_i = 0] = \mathrm{E}[C_i|S_i = 0]$.

require that couples who share similar characteristics are randomly assigned to separate or remain involved, which would be infeasible for obvious practical and ethical reasons. In this non-experimental setting, the couple's relationship status is likely non-random and depends on characteristics that may also influence the couple's child investment behavior. For instance, the couples' economic conditions can influence both their relationship stability and ability to care for their children. In what follows, the approach used to construct a suitable comparison group when random assignment is unavailable, namely the matching method, and the identifying assumptions on which it is based, are described.

Matching

Statistical matching is a way to identify a suitable control group that is comparable to the treated. This method is particularly useful in settings where data often do not come from randomized trials, but from (non-randomized) observational studies. Matching estimators try to re-establish the condition of an experiment by stratifying the sample of treated and untreated children with respect to covariates X that rule the selection into treatment. Selection bias is eliminated provided all variables in X are measured and comparable (or "balanced") between the two groups. In this case, outcome differences between the treated and controls provide an unbiased estimate of the treatment effect.

Conditional Independence Assumption (CIA)

The matching method pairs treated and control units with similar observable characteristics and assume that their relevant differences, in terms of potential outcomes, are captured in their observable attributes. This underlying assumption, called the conditional independence assumption (CIA henceforth), requires that conditional on observables X_i, the distribution of the counterfactual outcome $C_i(0)$ in the treated group is the same as the (observed) distribution of $C_i(0)$ in the non-treated group. In other words, the outcomes of the untreated are independent of participation into treatment S_i, conditional on observable characteristics X_i: $C_i(0) \perp S_i|X_i$. This rules out the possibility that variables not included in X_i, on which we cannot condition, affect both $C_i(0)$ and S_i (i.e., there is no selection on unobservables). It follows that, for a child whose parents separated with a given x, the outcomes of matched children whose parents remained romantically involved can be used to measure what his/er outcome *would have been*, on average, had his/er parents remained romantically involved. This assumes that there are untreated individuals for each x: $Pr(S_i = 0 \mid X_i = x) > 0$ for all x, implying that individuals are matched only over the common support region of X_i where the treated and untreated group overlap. Note that under the CIA, it is not necessary to make assumptions regarding the functional forms of the outcome equations, decision processes, or distribution of the unobservables.[13]

Average Treatment Effect for the Treated (ATET)

Following the CIA, the average treatment effect on the treated can be computed as follows:

$$\begin{aligned} \beta_{|S_i=1} &= E[C_i(1) \mid S_i = 1] - E[C_i(0) \mid S_i = 1] \\ &= E_X[E[C_i(1) \mid X_i, S_i = 1] - E[C_i(0) \mid X_i, S_i = 1] \mid S_i = 1] \\ &= E_X[E[C_i(1) \mid X_i, S_i = 1] - E[C_i(0) \mid X_i, S_i = 0] \mid S_i = 1] \\ &= E_X[E[C_i \mid X_i, S_i = 1] - E[C_i \mid X_i, S_i = 0] \mid S_i = 1] \end{aligned} \tag{4}$$

To estimate the ATET, one is to first take the outcome difference between the two treatment groups conditional on X_i, then average over the distribution of the observables in the treated population.[14]

Conditioning on X within a finite sample, however, can be problematic if the vector of observables is of high dimension. The number of matching cells increases exponentially as the number of covariates in X_i increases. Thus, it is possible that there will be some cells that contain only treated or untreated units, but not both, making the comparison impossible. Rubin (1979) and Rosenbaum and Rubin (1983) suggest the use of the *propensity score*, the conditional probability of selection into treatment: $p(X_i) = Pr(S_i = 1 \mid X_i = x) = E(S_i \mid X_i)$, to stratify the sample. In the present context, the propensity score is simply the conditional probability the parents of a given child would separate. They showed that by definition the treated and the non-treated with the same propensity score have the same distribution of X: $X_i \perp S_i \mid p(X_i)$. This is called the *balancing property* of the propensity score.

[13]The CIA assumption is strong because it is based on the assumption that the conditioning variables in X_i be sufficiently rich to justify the application of matching. In particular, CIA requires that the set of X_i should contain all the variables that jointly influence the outcome without treatment $C_i(0)$ as well as selection into treatment S_i (Heckman et al., 1998). To justify this assumption, econometricians implicitly make conjectures about what variables enter in the decision set of couples, and unobserved relevant variables are related to observables.

[14]The regression equivalent of this procedure requires the inclusion of all the possible interactions between the observables X_i.

Furthermore, if $C_i(0) \perp S_i \mid X_i$, then $C_i(0) \perp S_i \mid p(X_i)$. This implies that matching can be performed on $p(X_i)$ alone, which is more parsimonious than the full set of interactions needed to match treated and untreated on the basis of observables, thus reducing the dimensionality problem into a single variable.

Matching treated and untreated with the same propensity scores and placing them into one cell (i.e., observations with propensity scores falling within a specific range) is as if the selection into treatment is random within each cell and the probability of participation within this cell equals the propensity score. Consequently, the difference between the treated and the untreated average outcomes at any value of $p(X_i)$ is an unbiased estimate of the ATET at that value of $p(X_i)$. Therefore, an unbiased estimate of the ATET can be obtained by conditioning on $p(X_i)$:

$$\beta_{|S_i=1} = E_{p(X)}[(E(C_i \mid S_i = 1, p(X_i)) - E(C_i \mid S_i = 0, p(X_i))) \mid S_i = 1] \tag{5}$$

The implementation of this framework has several challenges. First, the propensity score itself needs to be estimated.[15] Second, since it is a continuous variable, the probability of finding an exact match for each treated child is theoretically zero. Therefore, a certain distance between the treated and untreated has to be accepted.

Matching Estimators

Various methods exist to implement matching estimates, all are based on the same strategy of pairing individuals but with different weighting schemes given to counterfactual individuals. Let T and C be the set of treated and untreated individuals, respectively. The observed outcome of a treated individual be denoted Y_i^T, and Y_j^C denotes the observed outcome of an individual in the control group. Let $C(i)$ be the set of control individuals matched to the treated individual i with an estimated propensity score p_i.

In general, *Kernel matching* matches all treated observations with a weighted average of all control observations with weights that are inversely proportional to the distance between the propensity scores

[15] The propensity score, i.e., the conditional probability that the parents of a given child would separate, can be estimated using any standard probability model. For example, $Pr(S_i|X_i) = F(h(X_i))$, where $F(.)$ is the normal or the logistic cumulative distribution and $h(X_i)$ is a function of covariates with linear and higher ordered terms. See Dehejia and Wahba (1998) for a description of the algorithm used to estimate the propensity score.

of treated and controls. The *kernel matching estimator* is given by:

$$\tau^k = (1/N^T)\sum_{i\in T}[Y_i^T - [(\sum_{j\in C} Y_j^C K((p_j - p_i)/h_n))/(\sum_{k\in C} Y_j^C K((p_k - p_i)/h_n))]]$$

where $K(\cdot)$ is a kernel function and h_n is a bandwidth parameter. In this study, we consider three matching estimators, namely *Uniform* (also known as the "radius" matching estimator), *Epanechinikov*, and *Gaussian* kernels, each uses a specific kernel function:

Epanechinikov: $K(u) = (3/4)(1-u)^2$ for $|u| < 1$, and 0 otherwise

Gaussian: $K(u) = (1/\sqrt{2\pi})exp[-u^2/2]$ for all u

Uniform (Radius): $K(u) = 1/2$ for $|u| < 1$ and 0 otherwise

Under the standard conditions on the bandwidth and kernel,

$$\sum_{j\in C} Y_j^C K((p_j - p_i)/h_n)/\sum_{k\in C} Y_j^C K((p_k - p_i)/h_n)$$

is a consistent estimator of the counterfactual outcome Y_{0i}.

The main difference between these matching estimators is in how weights are assigned to the matches. In *radius* matching, each treated unit is matched only with control units whose propensity score falls within a predefined neighborhood (i.e., radius) from its propensity score. All matches within this radius are assigned the same weight. If the dimension of the neighborhood (i.e., radius) is defined to be very small, it is possible that some treated units are not matched because the neighborhood does not contain any control units. Conversely, the smaller the size of the neighborhood the better the quality of the matches. With *Gaussian* and *Epanechinikov* kernel matching, all treated are matched with a weighted average of all controls, with the Gaussian kernel assigning weights that follow a normal distribution, and the Epanechinikov kernel assigning weights that follow a triangular distribution.[16]

Estimation using propensity score matching is now available via a set of Stata programs using the *pscore* package. Details of the algorithms used can be found in Becker and Ichino (2002). There are

[16] Depending on the choice of the bandwidth, the Gaussian kernel assigns positive weights to potentially poor matches (matches in which distance between the treated and controls are very far), while the Epanechinikov kernel assigns no weight to some potentially bad matches.

tradeoffs between the quantity and quality of the matches among these estimators but none is a priori superior. Relative to radius matching, the Gaussian and Epanechinikov matching tend to produce higher quantity of matches; however, the quality of the matches may be poorer since treated units are potentially matched with distant controls. Nevertheless, their joint consideration offers a way to assess the robustness of our results.

4 Data, Sample, and Descriptive Evidence

Our data are drawn from the Fragile Families and Child Wellbeing Study (FFCWS), which follows a cohort of $4,898$ children and both of their biological parents in 20 U.S. cities from birth (1998 $\sim$ 2000), at age one, and again when the child is about three years old.[17] The FFCWS is unique as it includes a large set of children born to unmarried parents. Areas such as parent-parent and parent-child relationships, socioeconomic activities, and child development are covered.

Sample Selection

Our study sample consists of $1,419$ children all born to parents who were unmarried but romantically involved at childbirth. The sample is selected in the following manner. First, given that the relationship arrangement between the biological parents is crucial for our study question, we exclude children whose parents' relationship status at either the one- or three-year follow-ups cannot be identified ($n = 1,733$ are dropped). Second, we focus on children born to unmarried biological parents who were romantically involved at childbirth (i.e. either in cohabiting or visiting unions), therefore children whose parents were either married (944 cases) or not romantically involved (302 cases) at childbirth are excluded. Third, we exclude children for whom we do not observe the outcome measure, i.e. whether they have developed asthma by age three (406 cases). Fourth, the parents of 32 of the remaining children had been married within the first year after childbirth, but divorced before their child reached age three. To avoid confounding the effect of separation between never-married parents and parental divorce, these observations are dropped.[18] Fifth, we cross check the marriage date (available since

[17] See Reichman et al. (2001) for a detailed description of the study design and sampling methods.
[18] We note that our results are robust to the inclusion of these observations (results available upon request).

the one-year follow-up) with parents' reported marital status at childbirth. Observations in which the reported marriage date contradicts the reported marital status of the parents at childbirth are dropped (9 observations). An additional 32 observations are dropped due to missing information on important socioeconomic and demographic characteristics.[19] In the resulting sample, consisting of $1,434$ children all born to unmarried parents, 37% of the parents have ended their (romantic) relationship by the time their child reaches age three.

Finally, we estimate the propensity score of selection into treatment (i.e. the probability of parental separation within three years since childbirth) within this sample of $1,434$ children. To ensure sufficient overlap of the propensity scores between the treatment and control groups, observations with propensity scores falling outside of the common support region are excluded from the analysis (7 treated and 8 controls), resulting in the final sample size of $1,419$ children.[20] Table 1 presents summary statistics of the measures employed in this study. Sample means are presented for the full sample (Columns 2 and 3) and by treatment status (Columns 4 and 5).

Measure of Child Health

Child health is measured by a child's likelihood of developing asthma by age three. Asthma is the most common chronic illness affecting children,[21] with symptoms formulated since infancy (Klinnert et al., 2001). Genetic predispositions combined with exposure to environmental toxins are common risk factors for asthma onset (Weisch et al., 1999; Sporik et al., 1991; Cogswell et al., 1987; Weitzman et al., 1990). In the U.S., children from lower socioeconomic and minority backgrounds develop higher rates of asthma, a pattern attributable to toxic environmental exposures and poor health investments (Neidell, 2004; Gergen et al., 1988; Oliveti et al., 1996).

Psychological stress is also known to aggravate asthma, and the relationship between stressful life

[19] To ensure that exclusion of these observations does not result in a selected sample (i.e. if the tendency of under-reporting is correlated with the treatment), we constructed missing indicators for each of these covariates and conducted t-tests of means for each of the missing indicators between the treated and control groups. None of the t-tests showed significant differences in the prevalence of under-reporting across the two groups (results available upon request).

[20] Imposing the "common support" restriction implies that the test of the balancing property is performed only on the observations whose propensity score belongs to the intersection of the supports of the propensity score of treated and controls. Imposing the common support condition in the estimation of the propensity score may improve the quality of the matches used to estimate ATET.

[21] "Asthma in Children Fact Sheet," American Lung Association, 2004.

events and the onset of asthma has been well established among the adult population (Teiramaa, 1979; Levitan, 1985; Kilel*ä*inen et al., 2002). Recent research also points to stress experienced by a caretaker as an independent factor contributing to child asthma (Wright et al., 2002).[22] Stressful life events, such as parental relationship conflicts, have been found to be associated with asthma onset in infants, mainly through the mother's coping abilities that translate into her parenting behavior (Klinnert et al., 1994).

In the FFCWS, mothers are asked to report whether her child has asthma or asthma attacks (or were informed by a health care professional that the child has asthma)[23] by age one, and again by age three. Within our sample, 25% report having asthma or an asthma attack by age three.[24] The incidence of asthma differs markedly by treatment status: a significantly higher proportion of children whose parents separated by age three reports having asthma (30%), relative to children whose parents remained romantically involved (22%).

Who Gets Separated?

While a number of recent studies examine the determinants of marriage among unmarried parents (e.g., Carlson et al., 2004; Goldstein and Harknett, 2006), the factors contributing to the dissolution of these unions have received little attention (see Liu and Heiland, 2007). Relationships that dissolve within three years after childbirth were potentially less stable at the onset. Parents in visiting relationships at the time of childbirth are more likely than cohabiting parents to separate within three years after a premarital birth: 26% of cohabiting parents as opposed to 57% of visiting parents end their romantic ties within three years after childbirth (not shown). Children whose parents separate are more likely the result of unplanned pregnancies, as indicated by the greater percentage of fathers who suggested

[22]Wright et al. studied the role of caregiver stress on infant asthma. Using a birth cohort with family histories of asthma to account for genetic predisposition, they find that greater stress levels experienced by caregivers when the child is 2 to 3 months old (before any symptoms of asthma can be detected) is associated with increased risk of recurrent episodes of wheezing (clinical definition of asthma) in children during the first 14 months of life. The findings are robust to established controls and potential mediators (including socioeconomic status, birth weight, race/ethnicity, maternal smoking, breast-feeding, indoor allergen exposure, and lower respiratory infections). In addition, the direction of causality runs from caregiver stress to levels of infant wheezing, rather than the reverse.

[23]This is consistent with the standard definition of childhood asthma, which is measured based on the response of a parent or adult household member ("America's Children: Key National Indicators of Well-Being, 2001," Federal Interagency Forum on Child and Family Statistics, Washington D.C.: U.S. Printing Office).

[24]According to the 2002 National Health Interview Survey, about 12% of U.S. children under the age of 18 are diagnosed with asthma, but the incidence is much higher among minority children (CDC, 2004). Diagnosing asthma in young children is more difficult than in older children, but an estimated 50% of kids with asthma develop symptoms by age two.

abortion during the pregnancy. Having an unplanned pregnancy can strain a romantic relationship, as it has been found to be associated with less positive interactions between spouses (Cox et al., 1989).

Studies of married couples have found husbands' socioeconomic characteristics to be positively correlated with marital stability, but not the wife's (e.g., Whyte, 1990). One of the most important barriers to a stable relationship is financial instability, as a father that cannot contribute to the economic wellbeing of the family is seen as a liability (Edin, 2000). Consistent with this argument, we find that fathers who separate from the child's mother tend to be younger, foreign-born, less educated, and less attached to the labor force, relative to fathers who remain romantically involved with their child's mother. Low levels of education and poverty are linked to risky and abusive behavior (e.g., Clark et al., 2004). Unmarried non-resident fathers have been found to exhibit these risk factors at higher rates than married or cohabiting fathers (Wilson and Brooks-Gunn, 2001; Jaffee et al., 2001). These risk factors may lead to lower father involvement with children both directly, or indirectly by weakening his relationship with the mother. Mothers may further mediate father involvement with the child even after their romantic relationship with the father has ended (Fagan and Barnett, 2003).

5 Estimation Results

Our descriptive evidence points to a negative association between parental separation and child's likelihood of developing asthma. However, one cannot readily conclude that this association is causal, as there may be factors that influence both the child outcomes and parental separation. Ideally, to determine whether this association is causal, we would have information on the potential outcomes of these children *if their parents had remained romantically involved*. Since the counterfactual outcome is never directly observed, and standard regression estimates based on the average outcomes of all control observations (many of whom may differ systematically from the treated) are potentially biased, an alternative statistical method to identify the counterfactual is needed. Matching methods is a semi-parametric method that can be used to reduce selection bias, by constructing a suitable control group whose outcomes are more likely to resemble the counterfactual outcomes of children whose parents separated if they had remained together.

In this setting, children who experience parental separation are compared only to children whose parents remain romantically involved but share very similar (environmental) characteristics, and not to children subjected to very different conditions in addition to their treatment status. Hence, the estimated effect of parental separation is the average of the typical effect of treatment on the treated only, and the differences in their outcomes are taken as driven only by their treatment status (i.e. the "causal" effect of parental separation on children whose parents separated).

The Propensity Score of Parental Relationship Dissolution

The first step in implementing the matching method is to estimate the propensity score for the treatment ("parental separation") under study: $Pr[S_i = 1|X_i]$. Parents' propensity to separate is defined as a function of each parent's socioeconomic and demographic characteristics, child-specific characteristics observed at childbirth, and measures of union match quality. Parameter estimates for the probit model used to match the treated and control groups of children are presented in Table 2. Consistent with our descriptive evidence (holding everything else constant), parents who did not co-reside at the time of childbirth ("visiting relationships") are significantly more likely to dissolve their romantic relationship within three years after childbirth. Unmarried fathers who are young (less than 20 years of age), foreign-born, poorly educated, and work few hours per week are significantly more likely to see their romantic relationship with the child's mother end within three years since childbirth.

Once the propensity score is estimated, we need to make sure that the treated and controls are (statistically) identical in terms of their observable characteristics X and their estimated propensity scores, but differ only in terms of their treatment status ("test of the balancing property"). The sample is stratified into 5 equally spaced intervals (or blocks) based on the predicted propensity score. We test (1) whether the average propensity scores and means of each covariate in X are (statistically) identical between the treated and control units within each interval, and (2) there is sufficient overlap of the propensity scores between the treated and controls within each interval, to ensure that adequate number of matches can be found for the treated units.[25] Table 3 reports results of the test of the balancing property between the treated and controls, which shows that the treated and controls within each interval to be comparable in their observable characteristics. In addition, Figure 1 reveals that

[25]For details of this test, see Dehejia and Wahba (1999).

there is sufficient overlap of the propensity scores between the treated and controls in each block.

Main Findings

Table 4 presents the estimated effect of parental separation on child's propensity to develop asthma by age 3. We first report the OLS estimates: column 2 shows the unadjusted mean differences in the prevalence of child asthma between the treated and controls (i.e., OLS regression without any controls), and column 3 reports the mean outcome difference after adjusting for a full set of controls. The propensity score matching estimates based on the Gaussian, Epanechnikov, and uniform kernel (radius) estimators, respectively, are reported in columns 4 to 8. To assess the sensitivity of the matching estimates to the choice of bandwidth (or radius), we also report results using different bandwidths (or radiuses). Details on the choice of bandwidth are discussed in the next section.

On average, children whose parents separate are 7.8% more likely to develop asthma by age 3 compared to children whose parents remain romantically involved. Differences in observable parental and child characteristics partially explain the outcome difference between the treated and controls: the separation effect is reduced to 5.2% (OLS) or 6.1% $\sim$ 7.1% (matching) but remains statistically significant. This finding suggests that selection into relationship separation helps explain the child outcome differences between children whose parents separate and those who do not. A notable share of unmarried fathers have disadvantaged characteristics that may not be conducive to increase engagement (or sustain romantic involvement), hence their relationship with the child's mother may have been less stable (or sustainable) from the onset. Hence, these factors may help explain the poorer health among out-of-wedlock children whose parents separate.

Recall that the OLS estimates the average treatment effect (ATE) and matching estimates the average treatment effect on the treated only (ATET). While our matching estimates confirm the direction of the separation effect suggested by the parametric estimate, they are consistently larger in magnitude. This indicates that non-marital relationship dissolution may not be as detrimental for child health as one might suspect (at least for some children whose parents separate). To see this, consider a child whose parents separate (treatment group). The finding that, on average, the outcome difference between a treated child and a child in the control group that does not (necessarily) share similar disadvantages is smaller (i.e., OLS) than the outcome difference between the same treated child and a control child that does share these disadvantages (i.e., matching) implies that at least for some children in the treated group, having their parents separate may not be as detrimental as if their parents had remained romantically involved. Given that caretaker stress level has been identified as an independent determinant of child asthma onset (Wright et al., 2002), this result is consistent with the hypothesis that separating from a "deadbeat" dad may indirectly benefit some children by reducing the mother's stress level and enhance her parenting (Waller and Swisher, 2006), in addition to potential increases in available resources for the child by allowing the mother to form new relationships (e.g., McLanahan and Sandefur, 1994).

Sensitivity Analysis

Choosing the Bandwidth

The matching estimates may be sensitive to the choice of bandwidth. The Silverman's rule-of-thumb (1986) may be used to select the optimal bandwidth:

$$\widehat{h} = 1.06 \times Min\{\widehat{\sigma}, R/1.34\} \times n^{-\frac{1}{5}}$$

where $\widehat{\sigma}$ = sample standard deviation, R = interquartile range (75^{th}-quantile $-$ 25^{th}-quantile), and n = sample size. The method is based on the assumption that the underlying distribution of $p(X)$ (the propensity score) is normally distributed. The rule-of-thumb will give reasonable results for all distributions that are unimodal, fairly symmetric and do not have fat tails. However, the rule-of-thumb may not be applicable in our case as the distribution of the estimated propensity score is far from normal (see Appendix Figure 1). As a result, the bandwidth suggested by the rule-of-thumb may be far from optimal. If the choice of bandwidth is too large, the treated and their matches tend to differ more on observable characteristics. As a result, the matching estimates tend to converge to that produced by the OLS. Our matching estimates using the bandwidth suggested by the rule-of-thumb ($\widehat{h} \approx 0.048$) is statistically equivalent to the OLS estimates. Hence, for our analysis smaller bandwidth(s) (0.010 and 0.005) are chosen to ensure closer matches between the treated and controls are used in the estimation.

Relaxing the Common Support Condition

Our estimates are based on observations with propensity scores falling within the common support, to ensure that there are sufficient overlap between the treated and control units to enhance comparability, which may improve the quality of our estimates. A potential drawback of imposing the common support condition is that as the sample may be considerably reduced, since observations with propensity scores falling outside of the common support boundaries are dropped, the estimated treatment effect may be sensitive to this sample restriction. Hence imposing the common support restrictions is not necessarily better (Lechner, 2001). Imposing the common support condition results in 8 control and 7 treated units being dropped from our main analysis. To ensure that our estimates are not sensitive to the exclusion of these observations, we relax the common support condition and re-estimate the ATET using all $1,434$ observations. Appendix Figure 2 presents the box plot of the propensity score overlap for this sample. Overall, the ATET estimates obtained by relaxing the common support condition are very similar to our main results (results available upon request).

Assessing the Conditional Independence Assumption

An identifying assumption of the matching method, namely CIA, requires that conditional on the observables, the distribution of the potential outcomes of the treated group in the absence of treatment is identical to the outcome distribution of the controls. Yet since the data are uninformative about the distribution of potential outcomes for the treated group in the absence of treatment, they cannot directly reject the CIA. Imbens (2004) proposes an indirect way of assessing its plausibility, relying on estimating a causal effect that is known to be zero. Specifically, the test involves estimating the causal effect of the treatment on a lagged outcome, with its value determined prior to the treatment itself. If it is not zero, this implies that the underlying conditional distribution of the potential outcomes of the treated under no treatment is not comparable to control outcomes. The power of this test is enhanced if the variable used in this proxy test is closely related to the outcome of interest.

A number of studies have found strong associations between low birthweight and subsequent poor lung function among children, including childhood asthma (e.g., Nepomnyaschy and Reichman, 2006). We estimate the "causal" effect of parents' separation within three years after childbirth on whether the child was of low birthweight (< 88 *oz*). A child's birthweight is realized before the treatment can take place, and potentially correlated with the child's subsequent propensity of developing asthma. All of our matching estimates show that parental separation has no effect on whether the child was of low birthweight (results available upon request).

6 Conclusion

This study documents a causal relationship between parental non-marital separation and child health among out-of-wedlock children. Using a recent and representative sample of children all born to unmarried parents in large U.S. cities and adopting a potential outcome framework to account for self-selection into relationship dissolution, we find that parental separation has a detrimental effect on child health. By matching children who share similar backgrounds but differ only in terms of whether their parents dissolve their romantic relationship, we find that out-of-wedlock children whose parents separate within the first three years after childbirth are $6\% \sim 7\%$ more likely to develop asthma by age 3, relative to if their parents *had remained romantically involved*.

Our findings are consistent with explanations that poor health investments and caretaker stress are important determinants of asthma among young children. In particular, we find that socioeconomic disadvantages of fathers are crucial in explaining relationship dissolution between unmarried parents. Similarly, the status and quality of unmarried parents' relationships seem to be important predictors of early paternal involvement (Carlson and McLanahan, 2004; Johnson, 2001). In addition to the lack of available resources as a result of having a "deadbeat" dad, having a partner who is unable (and potentially unwilling) to provide for the family may contribute to relationship instability and heightened stress level for the mother. If the mother were to maintain a romantic relationship with the father, as opposed to being single or forming new partnerships, she may experience greater socioeconomic hardships and tension with adverse effects on her parenting behavior. Our results are consistent with findings by Sigle-Rushton (2005), that men who fathered children out of wedlock are more likely to experience relationship instability, which are likely to militate against protective benefits of social bonds that a union may confer. Hence, promoting greater (or maintained) involvement between these parents may induce some parents to remain in unhealthy relationships (Allard et al., 1991; Raphael and

Tolman, 1997), with potentially undesirable consequences for the children involved.

The rise in unmarried parenthood and research suggesting that children from single parent families face disadvantages as adults, prompted recent policies geared toward responsible fatherhood initiatives and promoting greater involvement of fathers with their biological children (Harden, 2002). While there is evidence suggesting that the majority of unmarried fathers are highly involved in their child's lives, especially during the first few years after childbirth (McLanahan et al., 1998), studies of divorced fathers indicate that men often disengage from their children when their romantic relationship with the mother ends (e.g., Furstenberg and Cherlin, 1991). Even more controversial, government funding for programs promoting fathers' co-residence with their children through marriage are in place. While our findings generally support stronger paternal involvement and child support enforcements to protect out-of-wedlock children from socioeconomic hardship, policies that promote marriage between unmarried parents should be mindful that a notable share of the fathers that are targeted might have characteristics not conducive for healthy relationships.

Two caveats of this study should be noted. The matching approach addresses selection effects driven by differences in observable characteristics between children of separated and intact parents. It implicitly assumes that even if there are unobservable factors affecting both relationship dissolution and child outcomes, they are correlated and hence proxied by included controls. While we have access to an unusually detailed sets of observable characteristics including information on both parents' and the quality of their relationship, our estimates may still suffer from some selection bias due to unobservables affecting both parental relationship status and child outcomes such as the home environment and other family-level influences. Within-cluster matching (or "Differences-in-differences" matching) makes further attempts to account for selection on unobservables by requiring that observations in the control groups be identical to the treated ones in a dimension believed to be particularly important to capture common (unobserved) background influences (for an application to the context of out-of-wedlock childbearing and schooling see Levine and Painter, 2003). A possible application of this approach in our context is to require the children in the control group to come from the same family as the treated child. However, this is beyond the scope of the present study since it would require multiple children to be observed for each couple and such data are not available in the FFCWS.

Finally, while this study reports the effect of non-marital separation between the parents on child health, one may also be interested in how it compares to the effect of marital separation, holding union duration and other aspects constant. Although the FFCWS interviewed a sample of married parents with a newborn at baseline, the sample size (net of sample attrition by wave 3) of initially married parents is small and fewer than 5% (roughly 30 observations) divorced before their child reaches age 3. In addition, due to sample design, information on parents with a newborn in the FFCWS are limited to the observational period only: time after the birth of the focal child (who is more likely of higher parity than a child born to unmarried parents at baseline). As such, we have very little information on parents who are married at baseline prior to marriage (or even prior to childbirth) needed to account for important differences between married and divorced families. Hence, comparisons between the effects of marital *vs.* non-marital dissolution on child outcomes are beyond the scope of this study.

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TABLE 1: Sample Means by Relationship Status Three Years after an Out-of-Wedlock Birth

	Entire Sample		Parents' Relationship Status (3 Years after Childbirth)	
	Mean	[S.D.]	**Involved**	**Separated**
Child developed asthma by Age 3	0.249	[0.433]	0.221	0.298*
Parents Separated by Age 3	0.371	[0.483]		
Parents' Relationship at Childbirth				
Cohabiting	0.654	[0.476]	0.765	0.466*
Visiting	0.346	[0.476]	0.235	0.534*
Child Characteristics				
Child is of low birth weight ($<$ 88 oz)	0.107	[0.309]	0.108	0.105
Child is female	0.464	[0.499]	0.479	0.437
Child's birth order (mother):				
- 1^{st}	0.376	[0.485]	0.353	0.416*
- 2^{nd}	0.330	[0.470]	0.336	0.319
- 3^{rd} or higher	0.294	[0.456]	0.311	0.264^{+}
Parent's Demographic Characteristics				
Mother's age $<$ 20 at childbirth	0.228	[0.419]	0.197	0.279*
Father's age $<$ 20 at childbirth	0.111	[0.315]	0.089	0.149*
Father is younger than mother	0.195	[0.380]	0.207	0.175
Mother's race/ethnicity:				
- white	0.165	[0.371]	0.185	0.129*
- black	0.523	[0.500]	0.456	0.635*
- Hispanic	0.285	[0.452]	0.331	0.207*
- other	0.028	[0.164]	0.027	0.029
Father's race/ethnicity:				
- white	0.126	[0.332]	0.144	0.095*
- black	0.557	[0.497]	0.495	0.662*
- Hispanic	0.285	[0.452]	0.328	0.213*
- other	0.032	[0.175]	0.032	0.030
Mother and father of different race/ethnicity	0.145	[0.353]	0.143	0.150
Mother is foreign-born	0.111	[0.315]	0.147	0.051*
Father is foreign-born	0.218	[0.413]	0.209	0.234
Child's Household Income				
Income less than $10,000	0.202	[0.402]	0.163	0.269*
Income between $10,000 and $24,999	0.340	[0.474]	0.352	0.319
Income at least $25,000	0.458	[0.498]	0.484	0.412*
N	1,419		893	526

(Continued)

TABLE 1: Sample Means by Relationship Status Three Years after an Out-of-Wedlock Birth

	Entire Sample		Parents' Relationship Status (3 Years after Childbirth)	
	Mean	[S.D.]	**Involved**	**Separated**
Parents' Education				
Mother's education:				
- less than H.S. diploma	0.367	[0.482]	0.364	0.373
- high school diploma / GED	0.356	[0.479]	0.345	0.375
- some college	0.247	[0.432]	0.285	0.230
- bachelor & beyond	0.030	[0.170]	0.034	0.023
Father's education:				
- less than H.S. diploma	0.375	[0.484]	0.386	0.357
- high school diploma / GED	0.383	[0.486]	0.354	0.434^{*}
- some college	0.213	[0.410]	0.229	0.186^{+}
- bachelor & beyond	0.028	[0.166]	0.032	0.023
Father is less educated than mother	0.271	[0.445]	0.279	0.257
Parents' Labor Market Activities				
Mother works	0.190	[0.393]	0.199	0.175
Mother's weekly hours of work	35.75	[9.199]	36.08	35.10
Mother's annual labor income:				
- less than $\$10,000$	0.423	[0.495]	0.417	0.432
- between $\$10,000$ and $\$24,999$	0.432	[0.496]	0.424	0.444
- at least $\$25,000$	0.145	[0.353]	0.158	0.123
Father works	0.839	[0.368]	0.862	0.798^{*}
Father's weekly hours of work	43.71	[11.52]	44.11	42.88
Father's annual labor income:				
- less than $\$10,000$	0.280	[0.449]	0.264	0.315^{+}
- between $\$10,000$ and $\$24,999$	0.473	[0.500]	0.466	0.486
- at least $\$25,000$	0.247	[0.431]	0.270	0.199^{*}
Mother's labor income $>$ father's	0.121	[0.328]	0.145	0.071
Other Characteristics				
Mother is catholic	0.281	[0.450]	0.326	0.204^{*}
Mother reports no religious affiliation	0.128	[0.334]	0.123	0.137
Mother attends religious activities frequently	0.166	[0.372]	0.165	0.169
Parents' have known each other for $<$ 1 Year before pregnancy	0.245	[0.430]	0.236	0.260
Father suggested abortion during pregnancy	0.152	[0.359]	0.137	0.177^{*}
Prenatal smoking and/or drinking (mother)	0.268	[0.443]	0.263	0.278
Maternal grandmother's education ($>$ HS)	0.216	[0.412]	0.218	0.213
Mother's PPVT score (Year 3)	88.11	[11.15]	88.58	87.39^{+}
N	1,419		893	526

Notes: Sample means between "children whose parents remained romantically involved" and "children whose parents separated" by age 3 is statistically significantly different at the * = 5% level, $^{+}$ = 10% level.

TABLE 2: Probit Estimates of the Propensity Score

	Coefficient	Robust Standard Error	$P > \lvert z \rvert$
Child is of low birth weight ($<$ 88 oz)	-0.034	0.120	[0.780]
Child is female	-0.080	0.073	[0.278]
Child's birth order (mother):			
- (Ref: 1^{st})			
- 2^{nd}	-0.114	0.092	[0.214]
- 3^{rd} or higher	-0.170	0.104	[0.101]
Mother's age < 20	0.048	0.107	[0.652]
Father's age < 20	0.227	0.134	[0.091]
Father is younger than mother	-0.059	0.103	[0.565]
Parents' race/ethnicity:			
- (Ref: both black)			
- both white	-0.274	0.144	[0.057]
- both Hispanic	-0.122	0.150	[0.413]
- both other	0.312	0.397	[0.432]
- mother is white, father is non-white	-0.002	0.198	[0.992]
- mother is black, father is non-black	0.213	0.224	[0.343]
- mother is Hispanic, father is non-Hispanic	0.074	0.203	[0.717]
- mother is other, father is non-other	-0.218	0.465	[0.639]
Parents' region of birth:			
- (Ref: both U.S.)			
- mother is foreign-born, father is not	-0.403	0.278	[0.147]
- father is foreign-born, mother is not	0.308	0.122	[0.011]
- both parents are foreign-born	-0.318	0.183	[0.081]
Mother's education:			
- (Ref: less than HS)			
- H.S. diploma / GED	-0.059	0.156	[0.703]
- some college	-0.146	0.255	[0.567]
- bachelor & beyond	-0.440	0.424	[0.299]
Father's education:			
- (Ref: less than HS)			
- H.S. diploma / GED	0.250	0.150	[0.095]
- some college	0.174	0.251	[0.488]
- bachelor & beyond	0.344	0.422	[0.415]

(Continued)

TABLE 2: Probit Estimates of the Propensity Score

	Coefficient	Robust Standard Error	$P > \|z\|$
Father's education relative to mother's:			
- (Ref: same)			
- less	0.061	0.174	[0.725]
- more	-0.131	0.169	[0.439]
Child's household income:			
- (Ref: less than $10,000)			
- between $10,000 and $24,999	-0.153	0.112	[0.172]
- at least $25,000	-0.092	0.117	[0.428]
Parents' labor force participation:			
- (Ref: neither parents work)			
- both parents work	-0.092	0.361	[0.800]
- only mother works	0.358	0.423	[0.397]
- only father works	0.219	0.137	[0.109]
Mother's weekly hours of work	0.007	0.009	[0.450]
Father's weekly hours of work	-0.005	0.002	[0.034]
Mother's labor income exceeds father's	-0.538	0.336	[0.110]
Length of parents' relationship before pregnancy:			
- (Ref: more than 2 years)			
- less than 6 months	0.030	0.123	[0.807]
- 6 months to 1 year	0.173	0.112	[0.120]
- 1 to 2 years	0.029	0.095	[0.762]
Mother is catholic	-0.078	0.113	[0.490]
Mother has no religious affiliation	0.031	0.114	[0.786]
Mother attends religious activities frequently	-0.003	0.102	[0.978]
Father suggested abortion during pregnancy	-0.007	0.101	[0.946]
Maternal grandmother attained more than a high school education	-0.055	0.099	[0.576]
Prenatal smoking / drinking (mother)	0.105	0.089	[0.242]
Parents in visiting relationship at childbirth	0.604	0.085	[0.000]
Mother's PPVT score (Year 3)	-0.000	0.004	[0.965]
Constant	-0.570	0.441	[0.196]
Log Likelihood $= -821.31$			
Pseudo $R^2 = 0.132$			

Notes: [a] Additional controls for "mother's state of residence at childbirth" (14 state dummies) omitted here. [b] Region of Common Support $\in [0.05292221, 0.83660801]$.

TABLE 3: Test of Balancing Properties between the Control and Treatment Group (Two-Sample T-Test of Means): T-statistics Reported

	Block 1	Block 2	Block 3	Block 4	Block 5
Range of the Propensity Score	$[0.053, 0.200]$	$[0.200, 0.400]$	$[0.400, 0.600]$	$[0.600, 0.800]$	$[0.800, 0.837]$
N Treated	37	166	175	133	15
N Controls	264	392	169	62	6
			Two-Sample Test of Means: Significance Level $= 0.01$ $\lvert T \rvert$ **Statistic**		
Propensity Score	1.314	2.432	2.136	1.116	0.005
Child is of low birth weight (< 88 oz)	0.592	1.236	0.778	0.323	0.679
Child is female	0.105	1.006	0.150	0.897	0.400
Child birth order (mother):					
- (Ref: 1^{st})					
- 2^{nd}	0.640	0.660	1.185	2.102	1.405
- 3^{rd} or higher	1.173	0.751	0.308	0.226	0.679
Mother's age (< 20)	1.372	0.619	0.262	0.149	0.535
Father's age (< 20)	0.842	1.020	0.443	0.618	0.291
Father is younger than mother	0.316	0.906	1.587	0.120	0.623
Parents' Race/Ethnicity:					
- (Ref: Both parents are black)					
- Both parents are white	0.274	0.643	0.449	1.011	0.000
- Both parents are Hispanic	0.225	1.206	0.779	0.538	0.000
- Both parents are of "other" race/ethnicity	0.018	1.386	0.427	0.787	0.679
- Mother $=$ white, Father $\neq$ non-white	0.755	0.144	0.157	0.293	0.000
- Mother $=$ black, Father $\neq$ non-black	0.374	1.150	0.664	1.772	1.165
- Mother $=$ Hispanic, Father $\neq$ non-Hispanic	0.515	1.308	0.891	0.420	0.000
- Mother $=$ other, Father $\neq$ other	0.752	1.150	0.043	0.057	0.679
Parents' Region of Birth:					
- (Ref: Both parents are born in U.S.)					
- Mother is foreign-born (not Father)	0.032	0.069	0.025	0.000	0.000
- Father is foreign-born (not Mother)	1.114	1.490	0.717	1.140	0.400
- Both parents are foreign-born	0.966	1.210	2.104	0.682	0.000
Child household income: (Ref: $< \$10,000$)					
- between $\$10,000$ to $\$24,999$	0.452	0.267	0.057	0.251	1.405
- More than $\$25,000$	0.338	0.185	0.341	0.515	0.623
Parents' Educational Backgrounds:					
- (Ref: Less than HS)					

(Continued)

TABLE 3: Test of Balancing Properties between the Control and Treatment Group (Two-Sample T-Test of Means): T-statistics Reported

	Block 1	Block 2	Block 3	Block 4	Block 5
- Mother's education: H.S. diploma / GED	1.898	1.198	0.801	1.247	0.400
- Mother's education: some college	0.859	1.383	1.410	1.047	0.914
- Mother's education: bachelor and beyond	1.026	0.018	1.227	0.553	0.000
- Father's education: H.S. diploma / GED	1.530	1.055	1.041	2.422	0.734
- Father's education: some college	0.070	0.091	0.408	1.403	0.914
- Father's education: bachelor and beyond	0.515	0.333	1.312	0.057	0.000
Mother's education relative to father's:					
- (Ref: Same)					
- Father is less educated than Mother	1.355	1.897	1.229	0.230	0.167
- Father is more educated than Mother	0.164	0.245	0.561	0.666	1.371
Parents' labor force participation:					
- (Ref: Neither parents work)					
- Both parents work	1.018	0.453	0.585	0.334	1.648
- Only Mother works	0.000	0.650	0.247	0.571	0.167
- Only Father works	1.024	0.727	0.306	0.167	0.291
Mother's weekly hours of work	0.627	0.404	0.451	0.450	0.035
Father's weekly hours of work	0.396	0.713	1.918	0.506	0.077
Mother's labor inc. $>$ Father's labor inc.	1.065	1.462	0.025	0.000	0.000
Length of parents' relationship prior to preg.					
- (Ref: $>$ 2 yrs)					
- $\leq$ 6 months	1.527	0.293	0.781	0.509	1.165
- 6 months $\sim$ 1 year	0.400	0.414	0.855	0.900	0.623
- 1 year $\sim$ 2 years	1.050	0.587	1.673	0.230	1.031
Mother is catholic	0.451	0.084	0.291	0.862	0.623
Mother has no religious affiliation	1.547	1.691	0.837	0.148	0.914
Mother attends religious activities	1.608	1.482	1.005	0.874	0.465
(at least few times a week)					
Father suggested abortion during pregnancy	0.122	0.814	0.568	0.496	1.405
Maternal grandmother's education	0.450	0.439	0.742	0.077	0.679
(some college and beyond)					
Prenatal smoking or drinking (mother)	1.678	0.329	1.046	0.423	0.167
Parents in visiting relationship (baseline)	1.114	0.092	1.259	0.186	0.000
Mother's PPVT score (Measured at Year 3)	1.786	1.327	0.782	0.653	0.401

Notes: ^{a} $|T|$ statistics of the two-sample test of means for "mother's state of residence at baseline" (14 indicators) not reported here (available upon request).

FIGURE 1: Box Plot of the Propensity Score Overlap

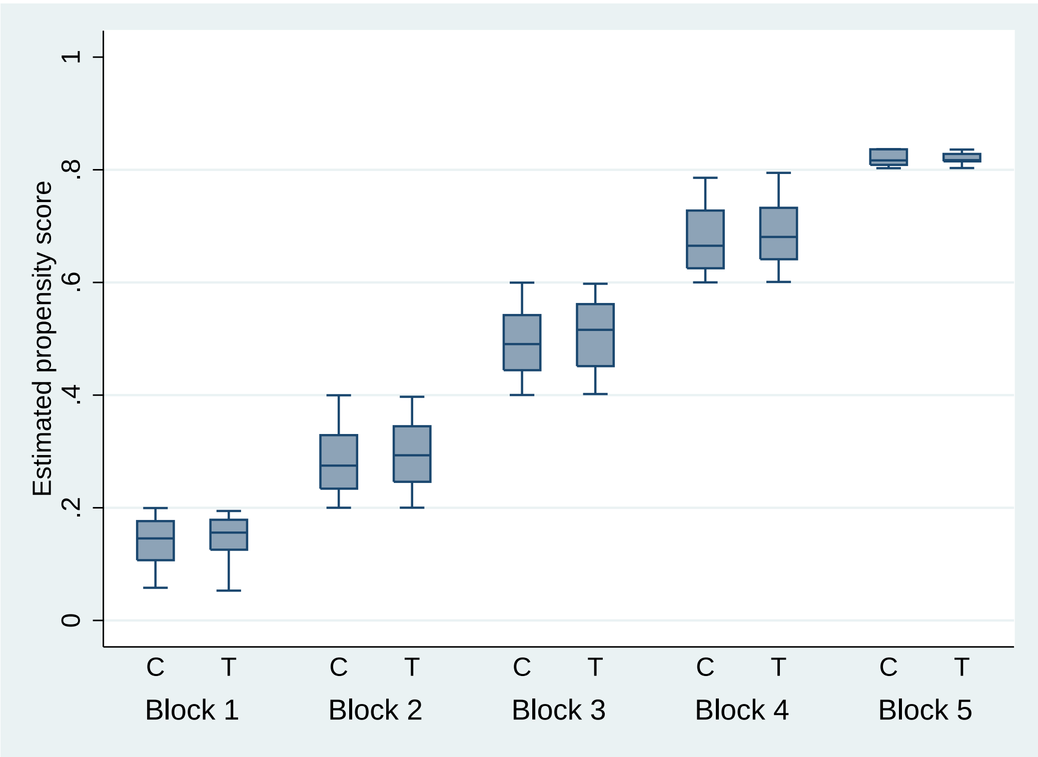


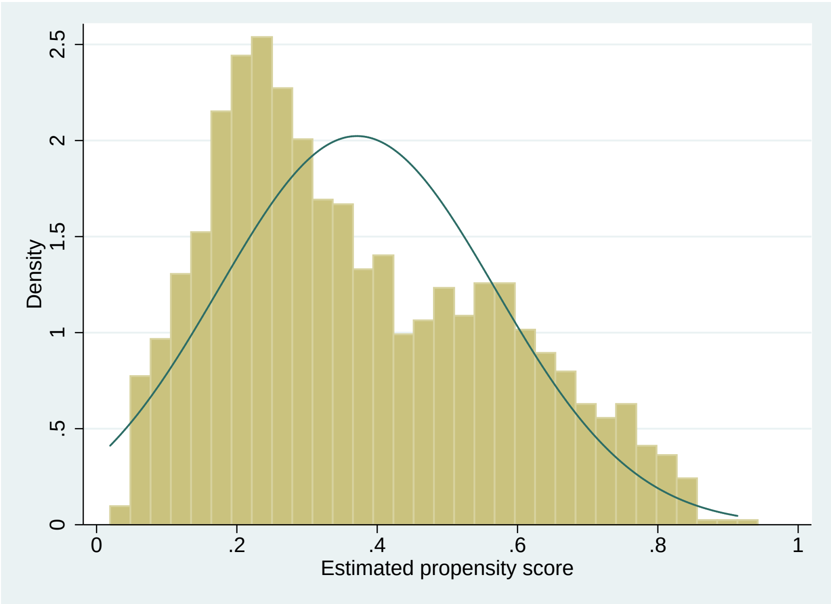
TABLE 4: Summary of the Effect of Parents' Separation on the Child's Likelihood of Developing Asthma by Age 3

	OLS		**Matching**				
	Un-adjusted	Adjusted	Gaussian	Epanechnikov		Uniform	
				($h = 0.01$)	($h = 0.005$)	($r = 0.01$)	($r = 0.005$)
Estimate	0.078*	0.052*	0.061*	0.071*	0.071*	0.067*	0.069*
Standard Error	[0.024]	[0.026]	[0.028]	[0.033]	[0.035]	[0.027]	[0.028]
N Treated	526	526	526	526	526	526	517
N Controls	893	893	893	893	893	880	862
% Matched Treated			100	100	100	100	98

Total Treated: $N = 526$
Total Controls: $N = 893$

Notes: [a] The OLS estimates of the separation effect without controls ("unadjusted") and with controls ("adjusted") are reported; [b] $h =$ bandwidth, and $r =$ radius; [c] Robust standard error reported for the OLS estimate, standard errors for the matching estimates are obtained by bootstrapping with 500 replications; [d] Propensity score is re-estimated at each replication of the bootstrap procedure to account for the uncertainty associated with the estimation of the propensity score; [e] Estimated propensity score in region of common support [0.05292221, 0.83660801], which is defined by the minimum estimated propensity score within the treatment group, and the maximum estimated propensity score within the control group; [f] The propensity score is estimated using a probit model with the following specification: $Pr[S_i = 1] = F$[Parents' relationship status at childbirth, child is of low birth weight, child gender, birth order of the child (mother), mother is less than 20 years old, father is less than 20 years old, father is younger than mother, both parents are white, both parents are Hispanic, both parents are of other race, mother is white (not father), mother is Hispanic (not father), mother is of other race (not father), mother is foreign-born (not father), father is foreign-born (not mother), both parents are foreign-born, mother's education, father's education, father is less educated than mother, father is more educated than mother, length of time parents knew each other before pregnancy, father suggested abortion during pregnancy, mother's PPVT score, mother is catholic, mother has no religious affiliation, mother attends religious activities frequently, prenatal smoking and/or drinking (mother), household income at childbirth, mother works (not father), father works (not mother), both parents work, mother's hours of work per week at childbirth, father's hours of work per week at childbirth, mother's labor income exceeds father's, maternal grandmother has some college education (or more), mother's state of residence at childbirth]

APPENDIX FIGURE 1: Distribution of the Estimated Propensity Score
(Relaxing the Common Support Condition)



APPENDIX FIGURE 2: Box Plot of the Propensity Score
(Relaxing the Common Support Condition)