Should We Get Married? The Effect of Parents' Marriage on Out-of-Wedlock Children

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January 12, 2007

Abstract

Using a representative sample of children born to unwed parents drawn from the Fragile Families and Child Wellbeing Study, this study investigates whether marriage after childbirth has a causal effect on early child cognitive ability, using a treatment outcome approach to account for the selection into marriage. Comparing children with similar background characteristics and parental mate-selection patterns who differ only in terms of whether their parents marry after childbirth, we find that children whose parents marry score about 4 points ($1/4th$ of a standard deviation) higher on the Peabody Picture Vocabulary Test at age three than children whose parents remain unmarried. Contrasting the estimates from potential-outcome and least squares models indicates that the marriage effect is greater for children whose parents transition into marriage. Further analyses show that their parents tend to be less well matched. In the absence of a legal arrangement ("marriage"), these parents may face lower incentives in allocating resources toward the child and may experience greater difficulties of coordinating and monitoring their investments. As a result, children of parents who transition into marriage could have been particularly at risk of receiving suboptimal investments had their parents remained unmarried.

Keywords: Premarital Childbearing, Child Wellbeing, Marriage, Assortative Mating, Propensity Score Matching

JEL Classification codes: J12, J13, C3.

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1 Introduction

While marriage remains the foundation of family life in the U.S., the traditional process of family formation, specifically marriage before having children, has been dwindling. The proportion of children born to unwed parents has increased dramatically over the past three decades, from 12% in 1970 to nearly one-third of all births today (Sigle-Rushton & McLanahan 2002*b*).[1] The decoupling of marriage and fertility behavior is particularly common among the low-income, less-educated urban population (Sigle-Rushton & McLanahan 2002a; Manning & Brown 2003; McLanahan & Sandefur 1994). Unmarried parents tend to have fewer resources, and children raised by unwed parents tend to display inferior outcomes compared to those raised by two married parents.[2]

Concerned over the rise of out-of-wedlock parenthood and its implications on children involved, recent policies have geared toward promoting marriage among unmarried parents.[3,4] However, very little is known about the potential benefits of marriage *after childbirth* for children born out-of-wedlock. Couples who have children out-of-wedlock are known to be selectively different from those who marry before having children. Unmarried parents tend to be of lower socioeconomic standing (Brown 2004; Osborne & McLanahan 2004),[5] face poorer prospects in the marriage market (Rosenzweig 1999), and may be less assortatively matched (Jaffe & Chacon-Puignau 1995; Garfinkel et al. 2002).[6] Hence, interpreting differences in child outcomes found in cross sectional comparisons between children born to married *vs.* unmarried parents as benefits of marriage could be misleading, as these differences may largely reflect the advantages of married parents rather than the intrinsic benefits of marriage.

This study examines whether marriage after having children has a causal effect on child cognitive ability, using data on a representative sample of children all born to unmarried parents drawn from the Fragile Families and Child Wellbeing Study (FFCWS). In this sample, a significant percentage

[1] Calculations of cohabitation trends from Census data are consistent with this development. In 1960, less than 1% of all couple-households were unmarried couples, compared to more than 8% in 2000 (see Fitch et al. 2005).

[2] See Ribar (2004) for a sweeping review of this literature.

[3] President Bush's Personal Responsibility and Welfare Reauthorization Act, for example, allocates a significant budget to programs promoting and stabilizing marriage (Garfinkel & McLanahan 2003).

[4] See Drewianka (2004) for a comprehensive discussion on policies aimed at promoting marriage.

[5] Nock (1998) finds that men who fathered children outside of marriage leave school earlier, have lower earnings, work fewer weeks per year, and are more likely to live in poverty compared to men who did not father children outside of marriage.

[6] Marriage is a highly selective process in which the correlations between traits of the partners are usually very high (such as age and education), given there are important complementarities in household production between the spousal traits (Becker 1991). Out-of-wedlock childbearing reduces the incentive for assortative mating, because the father is expected to play a smaller role in the household economy (Willis 1999).

of children born out-of-wedlock experience the marriage of their (biological) parents. To determine whether marriage after having children has a causal effect on child cognitive development, our empirical strategy centers around a treatment outcome framework similar to an experiment where the treatment ("marriage after childbirth") is randomly assigned.[7] We draw on matching methods (Rubin, 1979; Rosenbaum & Rubin 1983; Heckman et al. 1989, 1997, 1998) to identify the treatment effect (marriage), exploiting the full information provided by the rich set of parental characteristics in the FFCWS. Our approach addresses the selection into marriage by constructing the appropriate comparison group for children whose parents marry after childbirth. We first estimate the probability of marriage among unwed parents with a newborn, then compare cognitive outcomes of children whose parents have similar probabilities of marriage.

The treatment outcome framework is a (semi) nonparametric method that does not impose functional form assumptions on the relationship between the treatment ("marriage") and the outcome in question, thus allowing for heterogeneous treatment effects. In comparison, the linearity assumption of the conventional regression approach permits data from all observations to be combined into one estimate. The validity of such estimates is suspect when the combining function operates over children born to couples with very different characteristics (i.e., when unmarried couples with substantially different characteristics from those who marry are used to estimate the counterfactual). Hence, conventional estimates are complex averages of the typical effect of the treatment ("marriage") on the treated ("children whose parents marry"), and the effect of the treatment on those children whose parents are unlikely to ever marry. We investigate the role of heterogeneity in the marriage effect by comparing estimates from treatment outcome models (using propensity score matching) to least squares results.

In the estimation, we utilize information on the biological father that is rarely available in large representative datasets. The extent to which children benefit from their parents transitioning into marriage may depend on each parent's characteristics ("traits") and how well the parents' traits are matched ("positive assortative mating"). While some studies examine the determinants of (marital) union formation among single mothers (Furstenberg et al. 1987; Graefe & Lichter 2002; Aassve 2003), the factors influencing marriage and the patterns of assortative mating specifically between unmarried biological

[7] To assess the effect of parents' marriage on child outcomes, ideally one would design a natural experiment in which parents are randomly assigned into marriage. This, however, is problematic for ethical reasons and therefore practically infeasible.

parents are considerably less well understood.[8] This is mainly due to the lack of information on men who father children outside of marriage.[9] Confronted with the "missing fathers problem", studies typically account for selection into marriage by controlling for the characteristics of the resident parent (usually the mother) and assume that the mating patterns of unmarried parents are similar to those of married parents (e.g., Astone & McLanahan 1991; Wu & Martinson 1993; Wu 1996; Painter & Levine 2000).[10] To the extent that the effect of parents' marriage on the wellbeing of their children reflects both parental characteristics as well as the quality of their match, existing estimates of the effect of marriage among unwed parents may be biased.[11]

Data from the FFCWS is used to estimate the effect of marriage on child ability among out-of-wedlock children. The FFCWS provides child assessment data and detailed marriage, fertility, and socioeconomic information on both biological parents of a large representative sample of children born outside of marriage. We focus on the effect of marriage among parents who are romantically involved (cohabiting or visiting[12]) at birth on child cognitive ability, using scores from the Peabody Picture Vocabulary Test (PPVT), a widely-used interviewer-administered measure of receptive hearing and verbal ability.[13] Employing the treatment outcome framework to account for selection into marriage,

[8]Two recent studies examine determinants of marriage among unmarried parents with children using the Fragile Families and Child Wellbeing Study (FFCWS). Carlson et al. (2004) examines the determinants of marriage between unwed parents within one year after childbirth; and Osborne (2005) explore differences in the determinants of marriage between cohabiting and single parents. However, neither study explores the patterns of assortative mating among these unmarried parents.

[9]Finding a representative sample of nonresident fathers has proved extraordinarily difficult. In U.S. nationally representative surveys such as the Current Population Survey (CPS), the National Survey of Families and Households (NSFH), and the Survey of Income and Program Participation (SIPP), researchers have estimated that more than one fifth and perhaps as many as one-half of nonresident fathers are "missing," i.e., not identified as fathers (Cherlin et al. 1983; Garfinkel et al. 1998; Sorenson 1997). The problem is especially pronounced among black men and among men who fathered children outside of marriage, more than half of whom appear to be missing from American national surveys. Although longitudinal studies of divorced and separated fathers offer a more complete picture, even these suffer from non-inclusion and non-response bias (Garfinkel et al. 1998). A similar problem have been reported in British datasets (Paull et al. 2000).

[10]This assumption is frequently made by studies examining the potential economic contributions of non-resident fathers toward their children (Garfinkel et al. 1998; Garfinkel & Oellerich 1989; Miller et al. 1997; Sorenson 1997; Paull et al. 2000).

[11]Heiland and Liu (2006) use the FFCWS to examine the effects of parental relationship transitions within the first year since childbirth on children's health and behavioral outcomes measured at age one among children born to unmarried parents. Their study differentiates between various types of parental relationships, such as marriage, cohabitation, visiting (i.e., romantically involved but live separately), and no romantic involvement, and examines transitions between each of these types of relationship settings. However, they do not directly address the issue of self-selection into marriage, in addition to the shorter time span of the study period (within one year since childbirth). Osborne and McLanahan (2003) utilize the FFCWS to compare child outcomes measured at age three between children born to married, cohabiting then subsequently married, and persistently cohabiting parents. However, their study does not explicitly account for the self-selection into marriage.

[12]Couples who are romantically involved but living separately are termed to be in "visiting" relationships.

[13]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. Since unmarried families tend to be less stable and hence more short-lived (Bumpass & Lu 2000; Manning et al. 2004), findings from these studies may be characteristic of stable unmarried families only.

we find evidence that marriage is beneficial for child cognitive ability. Children whose parents marry after childbirth score about 4 points ($1/4th$ of a standard deviation) higher on the PPVT at age three, compared to children of persistently unmarried parents with similar observable characteristics.

The remainder of the paper is organized as follows. Section 2 discusses the conceptual context and existing evidence. Section 3 describes our statistical approach. Sample construction and descriptive evidence are discussed in section 4. Estimation results are presented in section 5. Section 6 concludes.

2 Background

While there is a large body of research on the relationship between family structure and child wellbeing, the effect of marriage between unwed biological parents on child outcomes has received little attention. We begin by providing some conceptual and empirical background for analyzing the effects of marriage on child wellbeing, with special emphasis on how marriage between the biological parents may benefit children born out-of-wedlock. We draw on the theoretical literature on family formation and resource allocation (Becker 1965, 1973, 1991; Manser & Brown 1980; McElroy & Horney 1981; Weiss & Willis 1997; Willis 1999; Ribar 2004) and stress the importance of family resources (time and money) and endowments (caregivers' ability) in the production of family public goods such as child quality.

2.1 Benefits of Marriage

Financial resources are key determinants of child development (e.g., Blau 1999), allowing the parents to purchase goods and services that benefit child development including shelter, food, and childcare. Economic resources are complemented by parenting resources—the services provided by the parents using their time and childrearing ability (e.g., McLanahan & Sandefur 1994). Interaction with the child fosters child development by providing support, stimulation, and control (e.g., Baumrind 1967; Maccoby & Martin 1983). For healthy child development, both time and material resources are needed (e.g., Coleman 1988). Parental time and income are substitutable to a certain extent as money can buy childcare services and working in the labor market increases available financial resources.

By forming a union, the availability of resources in the family can increase through several mechanisms (Becker 1991; Michael 1973; Shaw 1987; Drewianka 2004). First, individuals can realize gains

from specialization and exchange in the presence of comparative advantages: Households of married or cohabiting parents may capitalize on opportunities to divide responsibilities across partners according to their individual capacities. Specialization of partners' time is economically efficient as it exploits comparative advantages of each person in the production of goods that both enjoy (such as "child quality"). Second, individuals may realize economies of scale in household production (e.g., sharing the apartment). Third, the two-parent household can pool individuals' resources and realize gains from exploiting risk-sharing opportunities.[14] Fourth, individuals may become more productive as part of a family due to social learning. While these benefits apply to married couples and potentially to cohabitors as well, additional institutional factors that enhance resource availability such as tax laws and insurance coverage, are often exclusive to married couples.[15]

Non-marital arrangements lack the rights and responsibilities granted by the legal bond of marriage (Hamilton 1999; Lundberg & Pollak 1995). The marriage contract ensures that there is some compensation for sacrifices made on behalf of the family, thereby encouraging specialization and more defined parental roles (e.g., Brown 2004). Furthermore, marriage provides an environment that fosters the allocation of resources towards children since responsibilities and agreements are more easily enforced under family law and the cost of divorce reduces the risk of union dissolution.[16,17,18] For example, in the absence of a marriage contract, the father's incentive to invest in child quality may be low since he faces greater uncertainty regarding the extent to which he will enjoy the benefits of these investments in the future.[19] Moreover, given the greater difficulties for the father to monitor the effective use of his monetary transfers to the mother on behalf of the child outside of marriage, the father may make suboptimal investments in the child (Willis & Haaga 1996; Willis 1999).

[14]Contrary to this altruist model of the family pioneered by Becker, bargaining models emphasize each partner's own consumption and predict that spouses do not pool their incomes (McElroy 1990; Manser & Brown 1980; McElroy & Horney 1981).

[15]Married couples may also enjoy greater transfers from family members than cohabiting or visiting couples because of social norms and family traditions.

[16]Becker et al. (1977) argue that as the union becomes less stable, fewer investments in the relationship or other public goods, such as children, are made.

[17]The extent to which resources are allocated towards specific household public goods also depends on the bargaining power of the spouses. The latter reflects the opportunities a partner has outside the present union (McElroy 1990; Manser & Brown 1980; McElroy & Horney 1981).

[18]Stern et al. (1999) present a dynamic model of relationship formation and match quality that explains the transition from a cohabiting to a marital union. The risk of incurring the divorce costs reduces the expected gains from marriage and the returns to investment in parental roles and parenting skills. This implies that the search for the right partner becomes more important (i.e., the search process on average takes longer) and cohabiting unions, which serve as a trial marriage, become more common as divorce becomes more costly or likely.

[19]The same arguments applies when the child lives with the father. We note that, while the number of households with custodial fathers is on the rise (e.g., Meyer & Garasky 1993), they have remained the exception.

Consistent with the resource hypotheses, availability of economic resources is found to differ markedly across family arrangements, with children residing in mother-only or cohabiting-parents households being much more likely to live in poverty, compared to children in married two-parent families (Brown 2002). Cross-sectional studies suggest that income may explain up to half of the differences in child wellbeing between single-parent and two-parent families (McLanahan 1985). Hofferth (2001) estimates that among children under age 13, those living with single mothers spent 12 to 14 fewer hours with their parents per week compared to children living with married parents.[20] In addition, there is 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.[21]

While children in either married or cohabiting families may enjoy resources provided by two resident parents, Bauman (1999) finds that income of a cohabiting partner does less to amend the economic hardship than that of a spouse. Single parent and cohabiting families have been found to spend smaller shares of their budget on child-related goods, such as education (Ziol-Guest et al. 2004, DeLeire & Kalil 2005, respectively). Married couples are also more likely to pool their incomes compared to cohabitors (Winkler 1997; Bauman 1999; Kenney 2004; Lerman 2002; and Oropesa et al. 2003). Parenting resources may also suffer in cohabiting unions. Brown (2002) finds that cohabiting mothers are more likely to be psychologically distressed than married mothers and suggests that this difference may reflect stress due to greater uncertainty regarding the future of the union.[22]

This paper focuses on the effect of marriage between the biological parents on child wellbeing. The amount of resources allocated to the child may depend on whether or not the partner is biologically related to the child. Hamilton's kin selection model (1964), posits that genetic relatedness is a key determinant of transfers from parents. Biological parents may make greater investments in their children than non-biological parents for several reasons. First, biological parents may be more emotionally attached to the child and feel more responsible for the child's wellbeing. Similarities in physical and behavioral traits may reinforce this bond. Second, the returns from child investments may be higher

[20] Single parents may not be able 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 childrearing practices (e.g., Cherlin 1992; Thomson et al. 1994; Wu 1996; Wu & Martinson 1993). Conflicts between the parents over visitation may also encumber parenting effectiveness (Brown 2004).

[21] See Waite and Gallagher 2000 for a summary of this evidence.

[22] Kiernan (1999) argues that "the absence of the legal bond of marriage among cohabiting couples may represent less economic or emotional security, which may lie behind the higher dissolution rates invariably found among cohabiting parents compared with married parents".

for a biological parent. The father, for example, may be more involved if the child is his own since the child can continue his family lineage and ascertain future intergenerational transfers (Case et al. 2000). Third, the biological father may be required by law to pay child support regardless of his relationship status with the mother at childbirth.[23,24]

2.2 Selection into Marriage

Following the discussion in the previous section, a transition towards marriage is expected to result in greater availability of resources (economic or parenting) and increased paternal investments in the child. Despite evidence of out-of-wedlock childbearing occurring more frequently among the low-income and less-educated population (McLanahan & Sandefur 1994; Hao 1996; Sigle-Rushton & McLanahan 2002*b*; Manning & Brown 2003; Ellwood & Jencks 2004), most existing studies measure the benefits of marriage by comparing the wellbeing of out-of-wedlock children to children born to married parents, and pay little attention to the role of selection into marriage. This paper estimates the effect of marriage after childbearing among unwed couples with a newborn, and investigates the importance of the difference in the characteristics of couples who marry, as opposed to those who remain unmarried, in explaining the gap in the developmental outcomes of their children.

Economic theories of marriage posit that individuals optimally select a mate, exploiting the benefits from marriage discussed in the previous section subject to marriage market conditions and individual endowments (Becker 1973; Lam 1988; Manser & Brown 1980; McElroy & Horney 1981; Pollak 1995).[25] As a result, union formation tend to be non-random, but instead couples are expected to be positively assortatively matched in the presence of gains to marriage from production of household public goods and negatively assortatively matched in the presence of gains to specialization (Lam 1988). Spouses are typically found to be similar in age, race, educational attainment, and other socioeconomic characteristics (Epstein & Guttman 1984; Mare 1991; Oppenheimer 1988; Rockewell 1976), consistent with the idea that the production of household public goods is a primary source of the gains to marriage.

[23]The Family Support Act of 1988 requires states to establish legal paternity for all births, to develop and apply child support formulas based on a father's resources, and to establish stronger collection procedures.

[24]If the child is born out-of-wedlock and the father disputes paternity, the court determines paternity via DNA testing. However, child support laws thus far assume that the husband (at the time) is the father and enforce child support transfers if the birth occurs within marriage.

[25]For a recent empirical analysis of how marriage market conditions—in particular supply of available matches and externalities in spousal search—affect marriage rates, see Drewianka (2003).

The characteristics and mate selection patterns of parents with out-of-wedlock children who transition into marriage have received relatively little attention. Willis (1999) argues on theoretical grounds that unmarried parents should have less favorable characteristics and be less assortatively matched than married parents.[26,27] Consistent with these hypotheses, married parents are found to be of higher socioeconomic status than unwed parents (Weiss & Willis 1997; Sigle-Rushton & McLanahan 2002a; Brown 2004; Osborne & McLanahan 2004), and unmarried couples tend to be less (positively) assortatively matched (Jaffe & Chacon-Puignau 1995; Garfinkel et al. 2002). These differences in attributes and mating pattern likely contribute to the lower relationship quality and greater instability found among cohabiting and visiting parents compared to married parents (Brown & Booth 1996).[28]

The fact that selection into marriage among unwed parents is non-random complicates the estimation of the marriage effect on child wellbeing. Simple comparisons of child outcomes by marital status can be misleading if couples who get married are substantially different from those who remain unmarried in ways that also affect child investments. For example, if couples with characteristics that benefit child development are also more likely to get married after childbearing, compared to those who remain unmarried, then the benefits to marriage may be overstated. Conversely, if couples with poorer traits are more likely to get married, a negative association between marriage and child wellbeing may arise. For instance, the social stigma of non-marital childbearing may induce poorly matched or endowed couples to marry. In turn, the development of their children may be hindered as these parents may face greater difficulties in coordinating child investments. Given the limited understanding of the determinants of the transition into marriage among out-of-wedlock parents, the direction and magnitude of the potential selection biases in the estimates of the marriage effect remain unclear.

In this paper, we explore the role of selection into marriage using unique data from the FFCWS on the determinants of marriage, including characteristics of both biological parents, how long they

[26]Becker (1973, 1974, 1991) showed that when (1) there are at least as many men as women, and/or (2) women are in excess supply and lack the economic resources to bear children outside of marriage, an equilibrium assignment of matches between men and women occurs as all couples assortatively match to maximize the total gains across all possible matches, and all children will be born within marriage. Willis (1999) later showed that when women are in excess supply and are sufficiently economically self-reliant, another equilibrium in the marriage market exists: women from the lower economic strata—those with incomes (traits) sufficient to have a child but not to attract a high-income male to enter into marriage—would choose to bear children outside of marriage. Some unmarried men can father these children at a low cost, as they are not expected to play an important role in childrearing.

[27]The trend in out-of-wedlock childbearing is consistent with the shortage of eligible men due to mortality and incarceration differentials (esp. for African American women) and gains in women's economic wellbeing (Willis & Haaga 1996).

[28]Osborne (2005), using data from the Fragile Family Child Wellbeing Study (FFCWS), finds that out-of-wedlock mothers with higher education and earnings are more likely to transition into marriage after childbirth. However, she also provides some evidence that parents who transition into marriage may be less assortatively matched.

have known each other, whether the father suggested abortion, and other dimensions of match quality. We analyze which couples transition into marriage within the first three years of the child's life and who remain unmarried, and compare estimates of the effect of marriage on children from conventional models to results from a treatment outcome framework that accounts for selection into marriage.

3 Statistical Model and Estimation Strategy

In this section, we present a conceptual model of child investments and marriage for couples who experienced a premarital birth and introduce the empirical framework of the potential outcome approach. We then discuss the estimation strategy, namely the propensity score matching method and the identifying assumptions on which it is based.

3.1 Conceptual Model

Consider a couple i who have a child out-of-wedlock. The model of parental investments in their child and the process of marriage formation following childbirth can be formalized as follows:

$$C_i = \beta M_i + \gamma X_i + \varepsilon_i \quad (1)$$

$$M_i = \delta X_i + \nu_i \quad (2)$$

where C_i denotes the observed child outcome of couple i ("Child Quality"); M_i is a binary variable which equals to (1) if couple i marries after childbirth and (0) otherwise; X_i is a vector representing characteristics of couple i that may influence their child investment and marital decisions. Equation (1) says that child quality is influenced by parental marital status, observable characteristics X_i, and unmeasured factors ε_i. Equation (2) models the decision of the couple to marry after childbirth, which depends on observed characteristics X_i and unobserved factors ν_i.

If marriage is exogenous to the couple's child investment behavior, then ordinary least squares regression of the effect of marriage on child outcomes yields an unbiased estimate of the effect of parents' marriage after childbirth (β in (1)). However, a couple's child investment behavior might be endogenous to whether the couple transitions into marriage, i.e. if there is dependence between marital status (M_i) and the error term (ε_i). Correlation between M_i and ε_i can arise for one of two not necessarily

mutually exclusive reasons: (a) dependence between ε_i and ν_i; or (b) dependence between X_i and ε_i. The first case is referred to as *selection on unobservables* (Heckman & Robb 1985) and the second case as *selection on observables* (Rosenbaum & Rubin 1983).

The methodology followed in this paper pursues the selection on observables using propensity score matching (PSM).[29] The FFCWS enables us to construct measures of the biological parents' attributes and how assortatively matched they are. The PSM method matches children based on these factors (and other characteristics), thereby reducing potential bias induced by self-selection into marriage.[30]

3.2 Potential Outcome Approach

Using the terminology of the evaluation literature, consider the "treatment" to be the marriage between the biological parents of child *i* after his/her birth: $M_i = 1$ denotes the "treatment group" (i.e. children whose parents marry after childbirth), and $M_i = 0$ denotes the "control group" (i.e. children whose parents remain unmarried). Let $C_i(1)$ denote the potential outcome of child *i* under the treatment state ($M_i = 1$), and $C_i(0)$ the potential child outcome if the same child *i* receives no treatment ($M_i = 0$). Thus, $C_i = M_i C_i(1) + (1 - M_i)C_i(0)$ is the observed outcome of child *i*. The individual treatment effect is $\beta_i = C_i(1) - C_i(0)$, which is not observable since either $C_i(1)$ or $C_i(0)$ is missing. Alternatively, one might focus on the average effect of treatment on the treated ("effect of parents' marriage on children whose parents marry after childbirth"), i.e. the ATET henceforth:

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

[29] Instrumental variables (IV) is an alternative way to account for the endogeneity of marriage. However, finding a suitable instrument for marriage is extremely difficult. A good instrument must first be a strong predictor of marriage, but be unrelated to child wellbeing except through parents' marriage. State and local marriage restrictions have been used as instruments for marriage. However, they are potentially problematic for several reasons: First, state and local marriage restrictions may not detect any effects on marriage if few people are close to the margin where these restrictions matter; and secondly, even if these policies have measurable effects on marriage, they might only be enacted in areas with particular socioeconomic characteristics or as a result of concerns about local marriage and wellbeing trends (Ribar 2004). Furthermore, Card (1999) and Heckman et al. (1999) point out that instruments can also fail when there are differences across people in the effects of an event, like marriage, which subsequently affect people's decision-making. Consider the case in which there are exogenous variations in marriage restrictions across areas. In areas with burdensome restrictions, only people who foresee large gains to marriage will marry, while in areas with few restrictions, even people who foresee smaller gains will marry. In this case, the size of the marriage effect varies systematically with the otherwise exogenous costs of marriage.

[30] The unusually rich data on the determinants of marriage available in the FFCWS may also help to limit the extent of selection on unobservables. Potential bias from selection on unobservables is reduced to the extent that the X_i are proxying for unmeasured factors.

which is the difference between the expected outcome of a child whose parents marry, and the expected outcome of the same child if his/her parents were to remain unmarried.[31,32]

While we do observe the outcomes of children whose parents marry, and are thus able to construct the first expectation $E[C_i(1)|M_i = 1]$, we cannot identify the counterfactual expectation $E[C_i(0)|M_i = 1]$ without invoking further assumptions. To overcome this problem, one has to rely on children whose parents remain unmarried ($C_i(0)$), the comparison group, to obtain information on the counterfactual outcome. Replacing $E[C_i(0)|M_i = 1]$ with $E[C_i(0)|M_i = 0]$ 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 into treatment ensures that potential outcomes are independent of treatment status.[33] Hence, the treatment effect can be consistently estimated by the difference between the means of the observed outcomes in the treatment and the control groups. However, such experiment would be impossible in reality. In this non-experimental setting, a couple's marital decision is likely non-random: marital decision of a couple may depend on some observed characteristics which also influence the couple's child investment behavior. In this case, matching estimators can be devised as discussed in the next section.

3.3 Matching

Statistical matching is a way to construct a correct sample counterpart for the counterfactual outcomes of the treated had they not been treated (i.e. outcomes of children whose parents marry after childbirth had their parents remain unmarried). Since data on the counterfactual for the treated group is unavailable, matching estimators can be devised to reconstruct the condition of an experiment by stratifying the sample of treated and untreated children with respect to the covariates X_i that rule both the selection into treatment and the outcome under study. Selection bias is eliminated provided all variables in X_i are measured and balanced between the two groups. In this case, each stratum represents a separate randomized experiment and simple outcome differences between the treated and control groups provide an unbiased estimate of the treatment effect.

[31] It is thus necessary that each child is potentially exposable to any of the two treatments.

[32] At this stage, the stable unit-treatment value assumption (SUTVA) has to apply. In our case, it requires that the outcome of a given child depends only on his/her parents' marital decision, not on the marital decisions of other parents in the population (no peer effect).

[33] Randomization implies that: $M_i \perp (C_i(0), C_i(1))$ and therefore: $E[C_i(0)|M_i = 1] = E[C_i(0)|M_i = 0] = E[C_i|M_i = 0]$.

Conditional Independence Assumption (CIA)

An identifying assumption of the matching method is that the relevant outcome differences between any two children are captured in their observed characteristics, called the "Conditional Independence Assumption". It requires that, conditional on observables X_i, the distribution of potential child outcomes among married parents if these parents had remained unmarried to be the same as the outcome distribution of children with persistently unmarried parents, hence the outcomes of children whose parents remain unmarried ("untreated") are independent of their parents' marital decision M_i: $C_i(0) \perp M_i \mid X_i$. In other words, outcomes of children whose parents remained unmarried after childbirth are what the outcomes of children whose parents subsequently married *would have been* if their parents had remained unmarried (conditional on X_i).[34] Moreover, it assumes that, with positive probability, there are untreated individuals for each x.[35] It follows that $E[C_i(0) \mid X_i, M_i = 1] = E[C_i(0) \mid X_i, M_i = 0]$.[36] The conditional response of the *treated* under no treatment for a given X can thus be estimated by the conditional mean response of the untreated under no treatment.[37,38]

Average Treatment Effect for the Treated (ATET)

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

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

[34]This rules out possible unobservables affecting both $C_i(0)$ and M_i. In the analysis below, we utilize the rich set of measures of individual characteristics available in the FFCWS to specify the marriage matching functions.

[35]More specifically: $Pr(M_i = 0 \mid X_i = x) > 0$ for all x. This implies that individuals are matched only over the common support region of X_i where the treated and untreated group overlap. Consequently, the average treatment effect is computed only for those treated falling within the common support. Although the quality of the matches may be improved by imposing the common support restriction, high quality matches may be lost at the boundaries of the common support and the sample may be considerably reduced. Hence imposing the common support restrictions is not necessarily better (Lechner 2001). As part of the robustness analysis, the common support restriction will be relaxed during estimation.

[36]For further details, see Rosenbaum & Rubin (1983).

[37]This is simply to replace the unobserved outcomes of the treated had they not been treated with the outcome of untreated with the same X_i characteristics, given they are statistically equivalent.

[38]Note that under the "conditional assumption", it is not necessary to make assumptions regarding the functional forms of the outcome equations, decision processes, or distribution of the unobservables.

To estimate the average treatment effect on the treated, 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: $X_i \mid M_i = 1$.[39]

However, conditioning on X within a finite sample 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 increases. Therefore, it is possible that there will be cells that contain only treated or untreated individuals, but not both, making the comparison impossible. Rubin (1979) and Rosenbaum and Rubin (1983) suggest the use of the *propensity score*, i.e. the conditional probability of participating in the treatment $p(X_i) = Pr(M_i = 1 \mid X_i = x) = E(M_i \mid X_i)$, to stratify the sample. They showed that by definition treated and non-treated couples with the same propensity score have the same distribution of the full vector of observables X_i. This is the so-called *balancing property* of the propensity score: $X_i \perp M_i \mid p(X_i)$. Furthermore, if $C_i(0)$ is independent of M_i given X_i, $C_i(0)$ and M_i are also independent given $p(X_i)$. 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 biases of observables, thus reducing the dimensionality problem into a single variable $p(X_i)$.

Matching treated and untreated couples with the sample propensity scores and placing them into one cell (i.e., observations with propensity scores falling within a specific range) means that the decision whether to participate or not is random within each cell and the probability of participation in this cell equals the propensity score. Consequently, the difference between the treatment and the non-treatment average outcomes at any value of $p(X_i)$ is an unbiased estimate of the average treatment effect for the treated at that value of $p(X_i)$. Therefore, an unbiased estimate of the ATET can be obtained conditioning on $p(X_i)$, which is equal to exact matching on $p(X_i)$: $\beta_{|M_i=1} = E_{p(X)}[(E(C_i \mid M_i = 1, p(X_i)) - E(C_i \mid M_i = 0, p(X_i))) \mid M_i = 1]$.

The implementation of this framework poses some well-known challenges. First, the propensity score itself needs to be estimated. Second, since it is a continuous variable, the probability of finding an exact match is theoretically zero. Therefore, a certain distance between the treated and untreated couples has to be accepted. Several matching procedures have been proposed to solve this problem (see Becker & Ichino 2002 for a discussion). To estimate the ATET, this study employs *Kernel* esti-

[39] The regression equivalent of this procedure requires the inclusion of all the possible interactions between the observables X_i. The difference between regression and matching approaches is the weighting scheme used to average estimates at different values.

mators.[40,41] We refer to a technical appendix for a discussion of these estimators. There are tradeoffs between the quantity and quality of the matches among these estimators but none is a priori superior. However, their joint consideration offers a way to assess the robustness of our results.

4 Data and Descriptive Evidence

Our study sample consists of 958 children born to parents who were unmarried but romantically involved at childbirth drawn from the Fragile Families and Child Wellbeing Study (FFCWS). The FFCWS collected data on a cohort of approximately $4,898$ births in 75 hospitals in 16 large cities (with population of $200,000$ or more) across the U.S. between 1998 to 2000. The weighted sample is representative of all births in large cities in the U.S. in 1999.[42] The FFCWS is unique as it provides information on a large set of children born to unmarried parents in various living arrangements and relationship structures. Within the cohort, $3,600$ were born to unmarried parents, while the remaining were born to married parents. Both biological parents were interviewed at the time of childbirth ("baseline"), when the child reaches age one, and then at age three. Areas such as parent-parent and parent-child relationships, socioeconomic activities, and child development are covered.

In the three-year follow-up, the FFCWS collects data from a randomly selected subset of the core respondents on various domains of the child's environment,[43] called the "36-Month In-Home Longitudinal Study of Pre-School Aged Children". The Peabody Picture Vocabulary Test (PPVT) is administered to the child by the interviewer as part of the In-Home survey. The PPVT is a well-documented and widely-used measure of verbal ability and early scholastic aptitude. PPVT scores have been shown to be highly correlated with subsequent intellectual ability and achievement (Dunn & Dunn, 1981).[44]

Our study sample is selected as follows: First, given that the relationship arrangement between the biological parents is crucial for our study question, we exclude children for whom the relationship

[40] Various methods exist to implement matching estimates, all based on the same strategy of pairing individuals but with different techniques for pairing or different weights given to counterfactual individuals. This study implements three derivatives of kernel matching: Uniform (i.e. radius), Epanechnikov and Gaussian kernels.

[41] Matching can be done with or without replacement of the control units. Matching with replacement reduces bias but increase the variance. Here we use matching with replacement.

[42] For a detailed description and sampling methods used for the FFCWS, see Reichman et al. (2001).

[43] This information was collected through interviews with the child's primary caregiver, and direct observations of the child's home environment and interactions with his/er caregiver.

[44] Since the PPVT is based on receptive hearing of standard American English vocabulary, its cultural fairness has been debated (e.g., Washington & Craig, 1999). Our empirical analysis allows for racial and ethnic differences in verbal ability using information on both parents' race and ethnicity.

arrangement between the biological parents at either the one- or three-year follow-ups cannot be identified. As a result, $1,733$ children (35%) from the original cohort of $4,898$ children are dropped. Second, we focus on children born to unmarried biological parents who were at least romantically involved at baseline (i.e., either in cohabiting or visiting unions), therefore children born to married parents at baseline (944 cases) and children whose parents were not romantically involved (302 cases) are both excluded from the analysis.[45] At this stage, the sample size is $1,919$. Third, given the child outcome measures used in the analysis are available only through the "36-Month In-Home Longitudinal Study of Pre-School Aged Children", children who were not interviewed in the in-home survey (for whom we do not have outcome measures) are dropped (450 cases), resulting in a sample size of $1,469$ children. An additional 412 cases are dropped due to missing information on important socioeconomic and demographic characteristics.[46] Fourth, we cross check the date of marriage (available since the one-year follow-up) with parents' reported marital status at baseline. There are 6 observations in which the reported marriage date contradicts the reported marital status of the parents at baseline, and we drop these observations. In the resulting sample, consisting of $1,051$ children all born to unmarried parents, 19% experienced the marriage of their biological parents by age three [weighted $=$ 24%].

Finally, we estimate the propensity score of selection into treatment (i.e., the probability of parents' marrying within 3 years since childbirth) for the sample of $1,051$ 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 (6 treated and 87 controls are dropped), resulting in the final sample size of 958 children. Imposing the common support condition 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 control, and may improve the quality of the matches used to estimate the ATET (Becker & Ichino 2002).[47]

[45] The reasons for non-involvement may be plentiful (e.g., separation, surrogacy, etc.), and cannot be identified in the data. The process of marriage and child investments among non-involved parents likely differs in fundamental ways from romantically involved parents, warranting an approach that models these processes separately, a task beyond the scope of the present work.

[46] Observations with the following information missing are excluded: mother's self-reported health (baseline), mother's number of biological children (baseline), prenatal smoking and drinking (mother), father's race/ethnicity, mother's age at first birth, length of time parents have known each other prior to pregnancy, mother's education (baseline), and mother's frequency of attending religious activities. To ensure that exclusions of these observations do not result in a selected sample (i.e., the prevalence of under-reporting is correlated with the treatment), we construct missing indicators for each of these covariates and conduct t-tests of means for each of the missing indicators across the treated and control groups. None of the t-tests show significant differences in the prevalence of under-reporting across the two groups (results are available upon request).

[47] As part of our robustness analysis, and to ensure that our results are not potentially driven by common support restric-

4.1 Sample Descriptives

Table 1 presents summary statistics of the measures used in this study. Sample descriptives are first presented for the entire sample (Columns 1 through 4). Columns 5 and 6 present variable means conditional on whether the child's biological parents marry within the first three years after childbirth or not. An equality test of means for each variable is performed between the two sub samples. Table 1 shows that 64% of the parents were cohabiting at the time of childbirth, while the remaining were in "visiting" relationships.[48] Among children with parents who transition into marriage within three years after childbirth (20% of the sample), 81% (19%) had cohabiting (visiting) parents at birth.[49]

Child cognitive ability is measured by the child's standardized score on the PPVT test administered at age three.[50] Child PPVT scores in our sample range between 40 and 121, with an average of 84.9 and a standard deviation of 16. Children whose parents marry within three years since childbirth display significantly higher cognitive ability at age three, with an average PPVT score of 87.4, compared to an average of 84.3 among children whose parents remained unmarried.

4.2 Who Gets Married?

Examining transitions into marriage within three years after childbirth, we find that parents who marry after childbirth are better off in many dimensions compared to parents who remained unmarried (henceforth "persistently unmarried").[51] On average they are older, more educated, more likely to participate in the labor market, have higher earnings and household income. Mothers who are white or Hispanic are significantly more likely to marry their child's father after childbirth, compared to black mothers. Foreign-born mothers are also more likely marry after childbirth.[52]

Table 2 summarizes differences in (positive) assortative mating patterns between unmarried parents who marry after childbirth, and parents who remained unmarried. We examine disparities between the

tion, we re-estimate our models using the entire sample of $1,051$ children (i.e., without the common support condition).

[48]Couples who are romantically involved but living separately are termed as being in a "visiting" relationship.

[49]This finding is consistent with findings by Osborne (2005), that cohabiting mothers are more likely to marry within one year after childbirth than mothers who were in visiting relationships at baseline.

[50]The PPVT scores are normalized against a national population with a mean of 100 and a variance of 15 points.

[51]These patterns are consistent with earlier findings from the FFCWS: Carlson et al. (2004) found that couples with higher socioeconomic status are more likely to transition into marriage within one year after childbirth.

[52]Foreign-born parents who do not have legal status in the U.S. may be more inclined to marry the child's father if he is a U.S. citizen. Although we cannot identify the citizenship status of each parent, among mothers whose partner is born within the U.S., 30% of foreign-born mothers marry, compared to 20% of mothers who are born in the U.S. (results not shown).

partners' traits, such as age, education, race/ethnicity, and labor income. Overall, the age difference between the partners is larger for parents who marry after childbirth (2.9 years) than among persistently unmarried parents (2.5 years). There is also greater variation in the partners' age difference among parents who marry after childbirth. Although the percentage of cases where the mother is older than the father is similar regardless of parents' marital transition after childbirth, a larger fraction of mothers who marry their younger partner are over 25 years of age: Among children with a father who is younger than the mother, 63% of the mothers who marry their younger partner are over 25 years of age, compared to only 58% of persistently unmarried mothers.

Mixed-race unions are also more common among parents who marry after childbirth:[53] 16% of parents who marry after childbirth are of different racial background, compared to 14% of persistently unmarried parents. Further breaking down the composition of interracial couples by mother's race, we find that white and Hispanic mothers whose partners are of difference race/ethnicities are more likely to marry after childbirth, compared to black mothers.

Greater disparities in education assortment are found among parents who marry after childbirth, compared to persistently unmarried parents.[54] About 29% of parents who marry after childbirth are matches in which the mother is more educated than the father (compared to 27% of persistently unmarried parents). The prevalence of less assortment by education (i.e., the female being more educated than her male partner) also differs by mothers' education across the two sub-samples. Approximately 63% of mothers who marry their less-educated partner after childbirth have at least some college education, compared to 58% of persistently unmarried mothers who are more educated than their partner.

The prevalence of less assortment by labor earnings is similar among parents who marry after childbirth and those who remained persistently unmarried.[55] However, among mothers who earn more than their partners, mothers who marry after childbirth are relatively economically disadvantaged compared to persistently unmarried mothers: while the majority of mothers who marry their lower-earnings partners have incomes between $\$10,000$ and $\$25,000$ (62%), most persistently unmarried mothers with earnings higher than their partners have annual labor incomes of over $\$25,000$ (54%). This implies

[53] This is consistent with Osborne (2005), who finds that FFCWS parents who are of different racial backgrounds are more likely to marry within one year after childbirth.

[54] The education information collected by the FFCWS is categorical. Each parent's educational background is coded using his/er highest *level* of education completed. A mother is defined to be more educated than her partner if her highest level of education is strictly higher than her partner's.

[55] Please note that the statistics on labor earnings exclude unions in which at least one partner does not work.

that among children whose parents are less assorted by earnings (i.e., unions in which the mother has higher earnings than the father), those whose parents subsequently married may face greater economic disadvantages, compared to their counterparts whose parents remained unmarried.

In addition to patterns of assortative mating with respect to age, race, education, and labor income, we examine differences in various relationship characteristics between parents who marry after childbirth and persistently unmarried parents. Interestingly, parents who marry after childbirth are more likely to have rushed into marriage, given that they are more likely to have known each other for less than 6 months prior to pregnancy, compared to persistently unmarried parents (15% *vs.* 11%). Mothers who marry their child's father after childbirth are also more likely to be catholic and attend religious activities frequently.[56] We also find that the incidence of the father suggesting abortion is lower among parents who marry after childbirth compared to parents who remain unmarried. The father suggesting abortion during pregnancy may be an indication of whether the pregnancy was planned but also correlated with the father's attitudes towards abortion and marriage. For fathers who are against abortion, an unintended pregnancy may be a strong incentive to marry, even if the quality of the match between him and the mother is poor and/or uncertain.

5 Estimation Results

In this section, we explore the extent to which the outcome differences between children whose parents marry after childbirth, and children whose parents remained unmarried, can be attributed to benefits that come through marriage (after childbirth), as opposed to family characteristics correlated with marriage. As discussed above, we are interested in the outcomes of children whose parents marry *if their parents had remained unmarried*. Since the counterfactual outcome is never directly observed, information on children whose parents remained unmarried are used to estimate the counterfactual. However, parents who marry may be substantially different from parents who remained unmarried. Differences in child outcomes between these two groups potentially capture both the effect of parents' marriage and effect of other family characteristics, leading to a biased estimate of the "marriage effect".

In a standard parametric framework (i.e., OLS), the average cognitive outcomes of children whose

[56] Carlson et al. (2004) also find a strong positive correlation between mother's church attendance and subsequent marriage among unwed parents in the FFCWS.

parents marry (treatment group) are compared to the average outcomes of children whose parents remained unmarried (control group). The linearity assumption permits data on all observations to be combined into one estimate, but the validity of the estimate is suspect when the average outcome is taken over observations with very different characteristics (e.g., Levine & Painter 2003). Thus, the results tend to be sensitive to the choice of functional form. In addition, the estimation procedures create estimates that are complex averages of the typical effect of treatment on the treated (i.e., the effect of marriage on children whose parents marry) and the effect of the treatment on those whose parents are unlikely to ever marry.[57] Propensity score matching methods (PSM) relax the linearity assumption and allow for heterogeneous treatment effects between the treated and the controls. By matching each treated observation with controls who are very similar in their observable characteristics, the differences in their outcomes are taken as driven by their treatment status only. In this setting, the estimated marriage effect is the average of the typical effect of treatment on the treated only, rather than the average of the treatment effects on the treated and the controls.

Estimation results using conventional OLS regressions and propensity score matching are presented in this section. Note that if the assumptions of linearity and homogeneous treatment effects hold, then the OLS and matching estimates should produce very similar results. However, if the average effect of treatment on the treated vary substantially from the average treatment effect in the population, i.e., if the effect of marriage on children whose parents marry differ from the average effect of marriage on all children regardless of whether their parents transition into marriage, then propensity score matching yields a better estimate of the causal effect of marriage on children.

To understand the causal effect of marriage on children whose parents marry, characteristics of parents who select into marriage need to be analyzed. If the parents who marry differ substantially from parents who remained unmarried, i.e., if self-selection into marriage is important in explaining the differences in child outcomes, then we would expect the parametric (OLS) and semi-nonparametric (PSM) estimates to differ. Following the discussion in Section 2.2, if better-off parents are more likely to marry, the OLS would overstate the effect of marriage. Conversely, if parents who marry are worse-off, then the OLS results would understate the marriage effect, suggesting that the benefits of marriage are larger in magnitude among children whose parents marry compared to all out-of-wedlock children.

[57] This means that the average treatment effect on the treated (ATET) is assumed to be equivalent to the average treatment effect on the controls (ATEC).

5.1 Ordinary Least Squares Estimates

Table 3 presents the OLS estimates of the effect of parents' marriage after childbirth on children's PPVT score at age 3. The results using six different model specifications are presented. The "Baseline Model" shows the gross difference in the PPVT test scores between children whose parents marry, and children whose parents remained unmarried. On average, children whose parents marry score 3.073 points higher on the PPVT ($1/5th$ of a standard deviation) compared to children whose parents remained unmarried. Models 1 through 5 sequentially control for additional characteristics potentially correlated with the effect of marriage on child outcomes. Differences in basic family and child characteristics and household income partially explain the differences in child outcomes (Models 1 and 2).

As mentioned earlier, existing studies of the effect of family structure on children born to unwed parents often lack information on their birth fathers. As a result, studies typically resort to controlling for only the mother's characteristics to account for parental influences on child development. By doing so, these studies make the implicit assumption that the traits between unmarried parents are highly correlated, similar to married couples. This assumption may not be appropriate if unmarried parents are substantially different in their choices of mates compared to married couples. Therefore, to illustrate the importance of accounting for both parents' characteristics and their patterns of assortative mating, Model 3, 4, and 5 each additionally accounts for mother's characteristics, father's characteristics, and parents' patterns of assortative mating and match quality, respectively.[58]

Holding basic family and child characteristics, and household income constant, Model 3 additionally controls for mother's characteristics. The fit of the model improves significantly. Differences in mothers' characteristics account for 12% of the differences in the cognitive outcomes between children whose parents marry and children whose parents remained unmarried. If parental characteristics are highly correlated (i.e., parents match assortatively by their observed characteristics), additionally controlling for father's characteristics should not affect the magnitude of the estimated marriage effect, but only introduce more noise (i.e., larger standard errors). Model 4 shows that additionally controlling for biological father's attributes significantly reduces the differences in child outcomes, however the standard error on the effect of marriage also increased. Holding both parents' characteristics constant, children whose parents marry after childbirth have PPVT scores of 2.375 points higher ($1/7th$ of a

[58] All three models control for basic family and child characteristics and child's household income observed at the time of childbirth ("baseline").

standard deviation) than their counterparts whose parents remained unmarried. This difference remains statistically significant at the 5% level.

Finally, we examine whether parents' match quality can explain the remaining differences in child outcomes. In addition to controlling for each parent's socioeconomic and demographic characteristics, we control for parents' match quality measured by differences between the partners' traits and relationship-specific factors. By controlling for parental match quality, Model 5 shows that the differences in child outcomes are further reduced (while remaining significant at the 10% level).

5.2 Matching Estimates

Propensity score matching is a way to obtain estimates of the causal (unbiased) effect of marriage on child outcomes. The bias is reduced when the comparison of outcomes is performed using treated and control units with similar observable characteristics (i.e., family socioeconomic and demographic characteristics). In addition, the descriptive evidence and OLS estimates presented in the previous sections highlight the importance of both parents' traits and their relationship-specific characteristics (such as assortative mating patterns) in explaining the differences in child outcomes. To that end, we match the treated and control units based on a rich set of measures available in the FFCWS including measures of parents' match quality and relationship-specific characteristics, as well as each parent's socioeconomic and demographic characteristics.

To understand the causal effect of marriage and potential bias introduced through self-selection into marriage, the differences in the characteristics between the treated and the control groups need to be highlighted. Therefore, we first illustrate the factors affecting a couple's propensity to marry, namely the propensity score estimates. Then, the matching estimates are presented.

Estimating the Propensity Score of Marriage

The first step in implementing the matching method is to estimate the propensity score for the treatment ("marriage") under study. Parents' propensity to marry is defined as a function of each parents' socioeconomic and demographic characteristics, child-specific characteristics observed at baseline, and measures of union match quality.[59] Note that the majority of the parents who transition into marriage were

[59]The covariates X_i used in estimating the propensity score are identical to the fully-specified model (Model 5) in Table 3.

cohabiting at the time of childbirth ("baseline") (81%), while the remaining parents were romantically-involved but living separately (i.e., "visiting unions"). To ensure that our results are not driven by parents' relationship arrangement at baseline, parental relationship status at childbirth is included in estimating the propensity score.[60]

The propensity score for the treatment ("marry after childbirth") is estimated using a probit model[61] and following the algorithm proposed by Dehejia and Wahba (1998), which suggests grouping the observations into blocks defined based on the estimated propensity score and then test the balancing property within each block to ensure that the observables are sufficiently similar between the treated and controls within each block. Once the balance is achieved, the distributions of covariates X among the treated and control groups should be identical within each block.[62] Figure 1 shows the box plot of the propensity score within each block.[63] The figure reveals that there is good overlap in terms of the propensity score within each block, while in the extreme bins there is only limited overlap. This may be expected since the number of treated units increases and the number of control units decreases at high values of the propensity score. However this does not generate bias in the estimates as long as the balancing property is satisfied. This ensures that the treated and controls within each block are observationally identical and the only difference is their treatment status.

Table 4 presents probit estimates of the propensity score of selection into treatment, i.e. the probability of transitioning into marriage among unmarried parents with a newborn. Compared to persistently unmarried parents (holding everything else constant), unwed mothers who marry their children's fathers after childbirth (*i*) are (positively) assortatively matched in terms of their age, race/ethnic backgrounds, and labor incomes, but less (positively) assortatively matched by their educational backgrounds: Unions in which the male is less-educated than the female are more likely to transition into marriage;[64] (*ii*) are

[60] We conducted extensive robustness analysis of the effect of marriage among children born to visiting and cohabiting parents. Specifically, we estimated models using the sub-sample of children born to cohabiting parents only (640 observations). While the effect of marriage estimated from this more homogenous sub-sample was somewhat smaller, the benefits were still significant, suggesting that the results reported here are not driven by the heterogeneity between children with initially visiting *vs.* cohabiting biological parents. These additional results are available from the authors upon request.

[61] Estimating the propensity score using a logit model produces very similar results.

[62] For details of the test of the balancing property within each block, see Appendix Table 1.

[63] Note that our sample is restricted to observations within the common support, which is defined by the minimum estimated propensity score within the treatment group, and the maximum estimated propensity score within the control group. Observations with estimated propensity scores falling outside of this range are excluded from the analysis.

[64] Roempke, Graefe & Lichter (1999) use data from the National Longitudinal Survey of Youth (1979 Cohort) to examine women's propensity to transition into marriage after experiencing a premarital birth. They find a positive relationship between a woman's education and her likelihood of subsequently entering into marriage. However, their study does not account for the difference between the partners' education level. If unmarried mothers who marry after childbirth tend to be with partners who are less educated, and that this is particularly common among more educated women (as we have found),

significantly more likely to have known their children's fathers for less than six months prior to pregnancy; and (*iii*) attend religious activities frequently (i.e., at least a few times a week).

Given evidence that (positive) assortative mating, in particular with respect to education, enhances marital stability (e.g., Weiss and Willis 1997), our finding that parents who marry after childbirth are less positively assortatively matched with respect to education suggests that these unions are likely to be less stable. The fact that the couples who marry appear to have been together for less time prior to pregnancy, suggests that they may transition into marriage faster then planned (perhaps succumbing to social/religious pressures in the presence of an unplanned pregnancy), based on limited information about their partners and the potential quality of their match.

Matching Estimates

Table 5 presents the propensity score matching estimates of the effect of parents' marriage after childbirth on child PPVT score at age three. The effect of marriage on children whose parents marry (i.e., average treatment effect on the treated) based on the Epanechnikov kernel, Gaussian kernel, and radius (uniform kernel) estimators are reported, respectively. The joint consideration of kernel matching estimators with different weighting schemes provide a way to evaluate the robustness of the estimates. To assess the sensitivity of the estimates to the choice of bandwidth (or radius), results using different bandwidth (or radius) are reported.[65]

The matching estimates confirm the direction of the marriage effect suggested by the parametric results reported in Table 3: parents' marriage after childbirth has a significant positive effect on child cognitive ability at age three. However, the matching estimates are all larger in magnitude than the parametric estimates. Specifically, the matching estimates show that children whose parents marry

then the association between education and marital transitions found their study is consistent with ours.

[65] Silverman's rule-of-thumb (1986) may be used to select the optimal bandwidth:

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

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 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 ($\widehat{h} \approx 0.040$) is very close to the OLS estimates. Hence, we choose smaller bandwidth(s) (0.010 and 0.005) to ensure closer matches between the treated and controls are used in the estimation.

after childbirth, on average, score 3.5 to 4.4 points (approximately between $1/5th$ to $1/4th$ of a standard deviation) higher on the Peabody Picture Vocabulary Test (PPVT), compared to children whose parents remained unmarried. All estimates are statistically significant at the 5% level.

Comparing the magnitudes of the matching estimates to the parametric estimates, our results show that self-selection into marriage plays an important role in how parents' marriage affects child cognitive outcomes: the parametric estimates consistently *underestimate* the effect of marriage on child cognitive ability. The fact that matching produces larger positive effects than the parametric estimates implies that the beneficial effect of marriage on children whose parents marry is greater than the population average ("heterogeneous treatment effect").

The ATET sheds light on the potential outcomes of children whose parents marry if their parents had remained on married. Although couples who marry after having children tend to have more resources compared to persistently unmarried couples, they are also potentially less well-matched: they tend to have been acquainted for a shorter period of time prior to pregnancy, and may have decided to marry due to greater external social/religious pressure rather than a gradual progression towards more commitment. In addition, couples who marry after having children are found to be less assortatively matched by education, and lack of education assortment is found to be associated with relationship instability (Weiss and Willis 1997). Upon having a child, these parents may not have invested as much in their relationship compared to couples who have known each other longer. However, they decide to marry perhaps due to social pressure or higher stigma associated with childrearing in a non-marital arrangement. In the absence of a legal arrangement ("marriage"), lower incentives to allocate resources towards the child and greater difficulties in coordinating and monitoring investments, may translate into suboptimal child investments.

5.3 Robustness Analysis

Relaxing the Common Support Condition

Our estimates are based on observations with propensity scores falling within the common support ($N = 958$). This condition is imposed 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 restrictions is that high quality matches may be lost at the

boundaries of the common support and the sample may be considerably reduced. Hence imposing the common support restrictions is not necessarily better (Lechner 2001). Imposing the common support condition results in 87 control and 6 treated units being dropped from our main analysis. To ensure that our estimates are sensitive to the inclusion of these observations, we relax the common support condition (which includes these observations that were dropped) and re-estimate average treatment effects using the entire sample of $1,051$ observations.

Appendix Figure 1 presents the box plot illustrating the propensity score overlap for the entire sample. For treated individuals with high propensity scores (i.e., Block 7), there are no suitable controls (i.e., no overlap). In this case, treated observations with high propensity scores are potentially matched with control observations that are substantially different. This is particularly problematic for matching estimators that place positive weights on these "poor matches", such as the Gaussian kernel.[66] Appendix Table 2 reports the matching estimates of the effects of parents' marriage following childbirth on child cognitive ability at age three using the entire sample of $1,051$ children. Overall, with the exception of the Gaussian kernel estimate, the ATET estimates obtained by relaxing the common support condition are similar to our main results reported in the previous section.

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. Nevertheless, there is an indirect way of assessing its plausibility (Imbens 2003), 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. In this setting, being able to reject the null of no effect does not directly reflect on the hypothesis of interest. Nevertheless the power of this test is enhanced if the variable used in this proxy test is closely related to the outcome of interest.

[66] The Epanechnikov and uniform kernels can be used to bypass this problem since zero weights are placed on the potentially poor matches (i.e., matches in which the propensity scores of the treated and controls are very different), conditional on the selected bandwidth/radius is sufficiently small.

We assess the plausibility of the CIA by estimating the "causal" effect of parents' marriage after childbirth on the child's birth weight. A child's birth weight is realized before the treatment can take place, and potentially correlated with a child's subsequent development. Appendix Table 3 reports the matching estimates of the effect of parents' marriage after childbirth on child birth weight. The sample mean for child birth weight is 113.6 ounces with a standard deviation of 20.3 (not reported). All of our matching estimates indicate that parents' marriage has no effect on child birth weight (results available upon request).

6 Conclusion

The dramatic rise in out-of-wedlock childbearing over the past three decades and concerns over the potential adverse effects of non-traditional arrangements between the parents on child wellbeing have prompted policies aimed at encouraging marriage among unwed parents. The belief that the welfare of out-of-wedlock children is better protected if their parents get married is founded (at least in part) on evidence showing that children of unwed parents tend to exhibit inferior outcomes, compared to children born to married parents. While social scientists have cautioned that interpreting differences in child outcomes between children born to married *vs.* unmarried parents as "benefits of marriage" is inappropriate if couples who get married differ from those who do not in ways that affect child wellbeing, the importance of accounting for who gets married when estimating the effect of marriage on children has received little systematic attention.

This study presents new evidence on the benefits to marriage using a treatment outcome approach to account for the selection into marriage. Specifically, we investigate whether marriage after childbirth has a causal effect on the cognitive ability of children by comparing children with similar background characteristics and parental mate-selection patterns who differ only in terms of whether their parents marry after childbirth. Using a representative sample of children born to unwed parents, we find consistent evidence of a significant positive effect of parents' marriage after childbirth on child cognitive ability. Children whose parents marry after childbirth score about 4 points ($1/4th$ of a standard deviation) higher on the Peabody Picture Vocabulary Test at age three, compared to children of persistently unmarried parents who have similar observable characteristics.

Comparison of the propensity score estimates to conventional least squares results suggests that,

while there is a (modest) benefit of parents' marriage on child cognitive ability among all children born out-of-wedlock, these benefits are larger among out-of-wedlock children whose parents transition into marriage. While parents who marry after childbirth tend to be of higher socioeconomic status compared to persistently unmarried parents, we find that they do not know each other as well and are less assortatively matched in terms of education. The poorer match quality of the parents may explain the greater benefits to marriage enjoyed by their children. These children may see particularly large increases in parental investments once the legal arrangement that facilitates the enforcement of parental agreements and thereby encourages and helps coordinate and monitor the allocation of resources towards family public goods, is in place.

Our findings support the idea of encouraging marriage among unmarried couples with children. Given the observed heterogeneity in the marriage effect, the extent in which out-of-wedlock children may benefit from their parents getting married, can be expected to vary significantly due to the heterogeneity in the types of unmarried families. While marriage among parents in stable non-marital relationships is modestly beneficial, our findings suggest that the largest gains may be realized by children whose parents are less well matched and thus might receive insufficient inputs in the absence of parents' marriage. However, since these marriages are potentially less stable, programs intended to help stabilize marriages may be important complements to initiatives encouraging marriage.

Since the present work focuses on children born out-of-wedlock, our results do not readily speak to whether the large differences in child outcomes typically found between children born to married *vs.* unmarried parents should be interpreted as causal effects of marriage. We note that, although the FFCWS includes children born to married parents, an application of the potential outcome approach to assess the effect of marriage between children born to married *vs.* unmarried parents is infeasible since the survey does not provide enough information before childbirth. However, given our finding that out-of-wedlock children benefit from the marriage of their parents, it is conceivable that these children would have realized even better outcomes if their parents had married before having children.

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Table 1: Sample Descriptives

	Sample Mean	[S.D.]	Min.	Max.	Parents' Marital Status (after 3 Yrs. since Childbirth) **Married**	**Unmarried**
Dependent Variable					(Mean)	(Mean)
Child PPVT Score (Age 3)	84.91	[15.74]	40	121	87.37	84.30*
Parents' Relationship at Baseline						
Cohabitation	0.637	[0.481]	0	1	0.813	0.597*
Visiting	0.363	[0.481]	0	1	0.187	0.403*
Child Characteristics						
Child is of low birth weight ($<$ 88 oz)	0.099	[0.298]	0	1	0.081	0.103
Child is female	0.469	[0.499]	0	1	0.490	0.464
Child's birth order (with respect to mother):						
- 1^{st}	0.342	[0.474]	0	1	0.323	0.345
- 2^{nd}	0.329	[0.470]	0	1	0.333	0.328
- 3^{rd} or higher	0.304	[0.460]	0	1	0.328	0.299
Parent's Demographic Characteristics						
Mother's age (baseline): $<$ 20	0.242	[0.428]	0	1	0.177	0.257*
Father's age (baseline): $<$ 20	0.119	[0.324]	0	1	0.063	0.132*
Mother's race/ethnicity						
- White	0.156	[0.363]	0	1	0.214	0.143*
- Black	0.575	[0.495]	0	1	0.367	0.623*
- Hispanic	0.243	[0.429]	0	1	0.388	0.210*
- Other	0.025	[0.156]	0	1	0.031	0.023
Father's race/ethnicity						
- White	0.115	[0.319]	0	1	0.192	0.097*
- Black	0.615	[0.487]	0	1	0.414	0.661*
- Hispanic	0.238	[0.426]	0	1	0.369	0.208*
- Other	0.032	[0.177]	0	1	0.025	0.034
Mother is foreign-born	0.058	[0.234]	0	1	0.116	0.045*
Father is foreign-born	0.179	[0.383]	0	1	0.192	0.176
Parents' Education & Labor Market Activities						
Mother's educational background						
- High school diploma / GED	0.370	[0.483]	0	1	0.318	0.382+
- Some college	0.245	[0.430]	0	1	0.303	0.231*
- Bachelor and beyond	0.027	[0.161]	0	1	0.045	0.022
Father's educational background						
- High school diploma / GED	0.385	[0.487]	0	1	0.333	0.397+
- Some college	0.224	[0.417]	0	1	0.242	0.219
- Bachelor and beyond	0.024	[0.152]	0	1	0.076	0.012*
Mother works (baseline)	0.188	[0.391]	0	1	0.222	0.181
Mother's hours of work per week (baseline)	35.11	[9.065]	8	60	36.36	34.75
Mother's annual labor income (baseline)						
- Less than $\$10,000$	0.407	[0.493]	0	1	0.303	0.433
- Between $\$10,000$ and $\$25,000$	0.467	[0.500]	0	1	0.545	0.448
- More than $\$25,000$	0.126	[0.333]	0	1	0.152	0.119
Father works (baseline)	0.824	[0.381]	0	1	0.909	0.804*
Father's hours of work per week (baseline)	43.74	[11.29]	3	90	44.53	43.52
Father's annual labor income (baseline)						
- Less than $\$10,000$	0.295	[0.457]	0	1	0.242	0.311+
- Between $\$10,000$ and $\$24,999$	0.463	[0.499]	0	1	0.466	0.462
- More than $\$25,000$	0.242	[0.429]	0	1	0.292	0.227
Child's Household Income						
Less than $\$10,000$	0.219	[0.414]	0	1	0.137	0.239*
Between $\$10,000$ and $\$24,999$	0.348	[0.477]	0	1	0.355	0.347
More than $\$25,000$	0.433	[0.496]	0	1	0.508	0.415*
Sample size	958				192	766

Notes: Statistical significance of the equality test of means between "children whose parents marry after childbirth", and "children whose parents remained unmarried" at by age three are reported: $*$ = 5% level, and $+$ = 10% level.

Table 2: Patterns of Assortative Mating and Union Match Quality among Unmarried Parents with a Newborn

	Parents' Marital Status after 3 Years	
	Married	Unmarried
Age Differences†		
- Mean	2.880	2.539
- Median	2.000	2.000
- Standard Deviation	5.220	4.936
Father is younger than mother	19.57	19.57
By Mother's Age		
- Less than 20	2.78	4.17
- Between 20 and 25	33.33	37.50
- Over 25	63.89	58.33
Race / Ethnicity		
Mother and father of different race / ethnicity	15.79	14.25
By mother's race/ethnicity		
- Mother $=$ White, Father $\neq$ White	43.33	42.20
- Mother $=$ Black, Father $\neq$ Black	3.33	10.09
- Mother $=$ Hispanic, Father $\neq$ Hispanic	40.00	35.78
- Mother $=$ Other, Father $\neq$ Other	13.33	11.93
Education Differences		
Mother is more educated than father	29.17	27.01
By mother's education		
- Mother's education: High school diploma / GED	37.50	42.44
- Mother's education: Some college	55.36	49.76
- Mother's education: Bachelor and beyond	7.14	7.80
Labor Income Differences		
Mother's labor income exceeds father's labor income	2.43	2.24
By mother's labor income		
- Mother's annual labor income (between $\$10,000$ to $\$24,999$)	62.50	45.83
- Mother's annual labor income (more than $\$25,000$)	37.50	54.17
Other Characteristics		
Parents' have known each other for less than 6 months prior to pregnancy	14.58	11.49
Father suggested abortion during pregnancy	10.94	15.54^{+}
Mother is catholic	32.81	23.24^{*}
Mother attends religious activities frequently (few times a week)	22.92	15.27^{*}
Maternal grandmother's education: Some college or beyond	22.03	22.51
Unweighted N	192	766

Notes:

(1) Percentages reported;

(2) Statistical significance of the equality test of means between parents who marry after childbirth, and parents who remained unmarried are reported: $*$ = 5% level, and $+$ = 10% level;

† Age Difference is defined as "father's age $-$ mother's age at baseline (childbirth)".

Table 3**:** Effect of Parents' Marriage after Childbirth on Child PPVT Score Measured at Age 3 (Ordinary Least Squares)

	Baseline Model	Model 1	Model 2	Model 3	Model 4	Model 5
Parents married by age three	3.073*	3.085*	2.961*	2.603*	2.375*	2.158^{+}
	[1.277]	[1.263]	[1.250]	[1.176]	[1.205]	[1.224]
Additional Controls						
Basic Controls		Yes	Yes	Yes	Yes	Yes
Child's Baseline Household Income			Yes	Yes	Yes	Yes
Mother's Characteristics				Yes	Yes	Yes
Father's Characteristics					Yes	Yes
Parents' Assortative Mating Patterns & Match Quality						Yes
R^2	0.006	0.080	0.092	0.164	0.173	0.221
N	985	985	985	985	985	985

Notes:
(1) Robust standard errors reported in brackets [-];
(2) Statistical significance reported: $*$ = 5% level, and $+$ = 10% level;
Baseline Model includes no controls;
Model 1 adds "basic controls" to the Baseline Model, including: parents' relationship status at childbirth, child gender, child is of low birth weight, child birth order (mother), and mother's state of residence (baseline);
Model 2 includes all controls in Model 1, and adds controls for child's household income at baseline;
Model 3 includes all controls in Model 2, and adds controls for mother's age ($<$ 20), mother's race/ethnicity, mother is foreign-born, mother's educational background, mother works, mother's weekly hours of work, and mother's labor income;
Model 4 includes all the controls in model 3, and adds controls for father's age ($<$ 20), father's race/ethnicity, father is foreign-born, father's educational background, father works, father's weekly hours of work, and father's labor income;
Model 5 controls for each parents' age ($<$ 20), father is younger than mother, both parents are white, both parents are Hispanic, both parents are of Other race/ethnicity, mother is white (not father), mother is black (not father), mother is Hispanic (not father), mother is of Other race/ethnicity (not father), mother is foreign-born (not father), father is foreign-born (not mother), both parents are foreign-born, each parents' educational background, father is less educated than mother, father is more educated than mother, length of time parents' had known each other prior to pregnancy, father suggested abortion during pregnancy, mother's PPVT score (child age 3), mother is catholic, mother has no religious affiliation, mother attends religious activities few times a week, prenatal smoking (mother), prenatal drinking (mother), mother works (not father), father works (not mother), both parents work, each parents' hours of work per week, mother's labor income exceeds father's, and maternal grandmother's education.

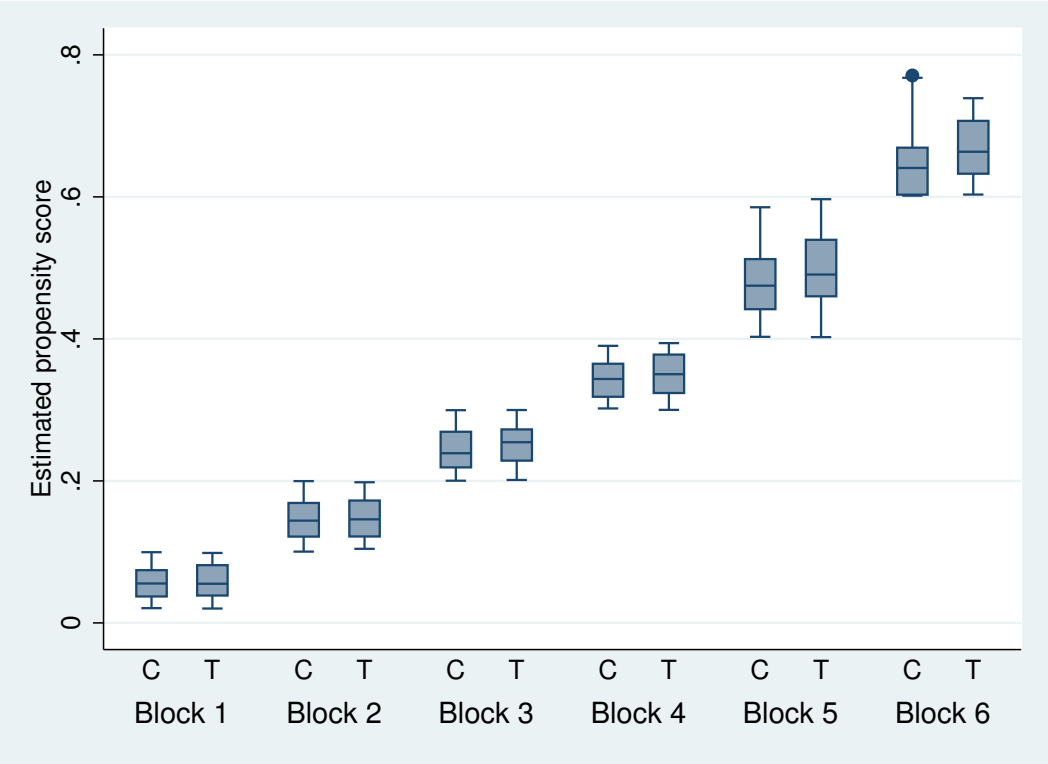


Figure 1: Box Plot of the Propensity Score Overlap

Table 4: Probit Estimates of the Propensity Score

	Coefficient	Robust Standard Error	$P > \|z\|$
Child is of low birth weight (< 88 oz)	-0.036	0.180	[0.840]
Child is female	0.022	0.103	[0.831]
Child birth order (mother): (Ref: 1^{st})			
- 2^{nd}	0.138	0.131	[0.294]
- 3^{rd} or higher	0.182	0.147	[0.217]
Mother's age (< 20)	-0.208	0.153	[0.171]
Father's age (< 20)	-0.192	0.210	[0.361]
Father is younger than mother	-0.058	0.140	[0.678]
Parents' Race/Ethnicity: (Ref: Both parents are black)			
- Both parents are white	0.236	0.193	[0.222]
- Both parents are Hispanic	0.602	0.198	[0.002]
- Both parents are of "other" race/ethnicity	0.049	0.571	[0.931]
- Mother is white, Father is non-white	-0.033	0.250	[0.894]
- Mother is black, Father is non-black	-0.617	0.530	[0.244]
- Mother is Hispanic, Father is non-Hispanic	-0.460	0.255	[0.071]
- Mother is of other race/ethnicity, Father is white/black/Hispanic	0.199	0.659	[0.763]
Parents' Region of Birth: (Ref: Both parents born in U.S.)			
- Mother is foreign-born (not Father)	0.264	0.374	[0.481]
- Father is foreign-born (not Mother)	0.108	0.178	[0.543]
- Both parents are foreign-born	0.489	0.266	[0.066]
Parents' Educational Backgrounds: (Ref: Less than HS)			
- Mother's education: high school diploma / GED	-0.399	0.210	[0.057]
- Mother's education: some college	-0.588	0.342	[0.086]
- Mother's education: bachelor and beyond	-0.857	0.553	[0.121]
- Father's education: high school diploma / GED	0.291	0.203	[0.152]
- Father's education: some college	0.509	0.341	[0.135]
- Father's education: bachelor and beyond	1.917	0.554	[0.001]
Father's Education relative to Mother's Education: (Ref: Same)			
- Father is less educated than Mother	0.463	0.236	[0.050]
- Father is more educated than Mother	-0.335	0.230	[0.145]
Child household income: (Ref: less than $\$10,000$)			
- between $\$10,000$ to $\$24,999$	0.010	0.163	[0.950]
- more than $\$25,000$	-0.020	0.170	[0.904]
Parents' labor force participation: (Ref: Neither parents work)			
- Both parents work	-0.356	0.513	[0.488]
- Only Mother works	-0.137	0.622	[0.825]
- Only Father works	0.062	0.216	[0.775]
Mother's weekly hours of work	0.013	0.013	[0.311]
Father's weekly hours of work	0.007	0.003	[0.042]
Mother's labor income $>$ Father's labor income	-0.087	0.391	[0.824]
Length of parents' relationship prior to pregnancy (Ref: $X > 2$ years)			
- ≤ 6 months	0.354	0.163	[0.030]
- 6 months $< X \leq 1$ year	-0.202	0.171	[0.238]
- 1 year $< X \leq 2$ years	0.113	0.129	[0.378]
Mother is catholic	-0.190	0.153	[0.212]
Mother has no religious affiliation	-0.005	0.160	[0.973]
Mother attends religious activities at least few times a week	0.472	0.136	[0.001]
Father suggested abortion during pregnancy	-0.045	0.154	[0.770]
Maternal grandmother's education (some college and beyond)	0.125	0.135	[0.354]
Prenatal smoking (mother)	0.248	0.132	[0.060]
Prenatal drinking (mother)	-0.464	0.206	[0.024]
Parents in visiting relationship (baseline)	-0.486	0.128	[0.000]
Mother's PPVT score (Year 3)	0.015	0.006	[0.006]
Log Likelihood $= -420$			
Pseudo $R^2 = 0.174$			
$N = 958$ (Treated $= 192$; Control $= 766$)			

Notes: (1) Additional controls for "mother's state of residence at baseline" (14 state dummies) omitted here; (2) Region of Common Support $\in [0.02025512, 0.77094784]$

Table 5**:** Effect of Parents' Marriage after Childbirth on Child PPVT Score Measured at Age 3 (Propensity Score Matching)

	Matching Estimate	S.E.	*N* Treated	*N* Controls	% Matched Treated
Epanechnikov Kernel					
Bandwidth = 0.01	3.500*	1.717	192	766	100
Bandwidth = 0.005	4.366*	1.791	192	766	100
Gaussian Kernel	3.610*	1.830	192	766	100
Radius					
Radius = 0.01	3.524*	1.404	189	765	98
Radius = 0.005	3.914*	1.487	182	697	95
N Treated (Total)= 192					
N Controls (Total)= 766					

Notes:

(1) Standard errors are obtained by bootstrap with 500 replications;

(2) 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;

(3) Estimated propensity score in region of common support $[0.02025512, 0.77094784]$, which is defined by the minimum estimated propensity score within the treatment group, and the maximum estimated propensity score within the control group;

(4) The propensity score is estimated using the probit model, using the following specification:

$Pr[M_i = 1] = F$[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 prior to pregnancy, father suggested abortion during pregnancy, mother's PPVT score, mother is catholic, mother has no religious affiliation, mother attends religious activities few times a week, prenatal smoking (mother), prenatal drinking (mother), household income (baseline), mother works (not father), father works (not mother), both parents work, mother's hours of work per week (baseline), father's hours of work per week (baseline), mother's labor income exceeds father's, maternal grandmother has some college education (or more), mother's state of residence (baseline)];

(5) Refer to Appendix Table 1 for details of tests of the "balancing properties" between the treated and controls with respect to each covariate.

Appendix Table 1: Test of Balancing Properties between the Control and Treatment Group (Two-Sample T-Test of Means): T-statistics Reported

Range of the Propensity Score	Block 1 [0.020, 0.100]	Block 2 [0.100, 0.200]	Block 3 [0.200, 0.300]	Block 4 [0.300, 0.400]	Block 5 [0.400, 0.600]	Block 6 [0.600, 0.771]
N Treated	19	37	38	47	38	13
N Controls	286	223	134	75	38	10
	Two-Sample Test of Means: Significance Level $= 0.01$ $\lvert T \rvert$ **Statistic**					
Propensity Score	0.557	0.565	1.541	1.376	1.222	0.528
Child is of low birth weight ($<$ 88 oz)	0.042	1.471	0.293	1.454	1.021	0.186
Child is female	0.253	1.144	1.346	0.185	0.453	1.125
Child birth order (mother):						
- (Ref: 1^{st})						
- 2^{nd}	0.260	2.146	0.451	0.849	1.194	1.326
- 3^{rd} or higher	0.528	0.621	0.937	0.606	1.217	0.636
Mother's age ($<$ 20)	0.345	0.894	1.146	0.066	0.585	0.000
Father's age ($<$ 20)	0.478	0.254	1.072	0.186	1.021	0.000
Father is younger than mother	0.194	0.012	0.033	0.673	0.000	1.181
Parents' Race/Ethnicity:						
- (Ref: Both parents are black)						
- Both parents are white	1.223	0.470	1.076	0.703	1.526	1.181
- Both parents are Hispanic	0.718	0.052	1.395	1.070	0.230	0.762
- Both parents are of "other" race/ethnicity	1.565	0.884	1.207	0.790	0.000	1.148
- Mother $=$ white, Father $\neq$ non-white	0.869	0.562	0.445	0.686	0.583	1.288
- Mother $=$ black, Father $\neq$ non-black	0.737	0.619	0.000	0.000	0.000	0.000
- Mother $=$ Hispanic, Father $\neq$ non-Hispanic	0.222	0.246	1.189	0.588	0.000	1.288
- Mother $=$ other, Father $\neq$ other	0.447	1.099	0.927	0.790	1.434	1.148

(Continued)

Appendix Table 1 **(Continued):** Test of Balancing Properties between the Control and Treatment Group (Two-Sample T-Test of Means): T-statistics Reported

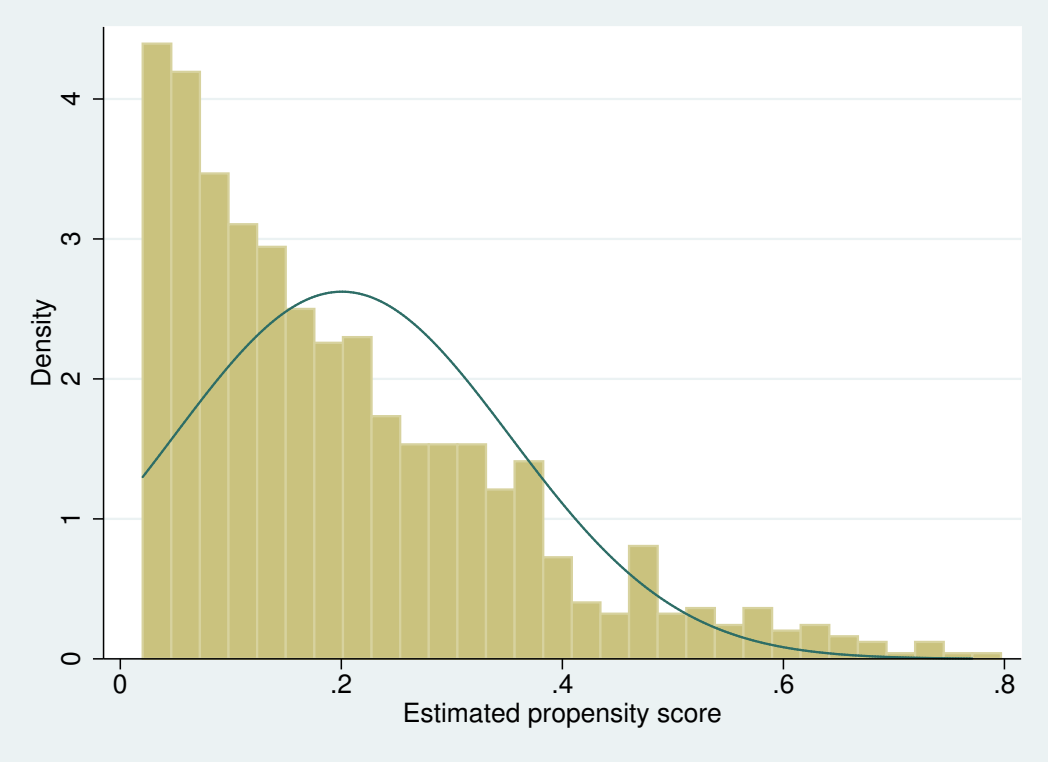
Range of the Propensity Score	Block 1 [0.020, 0.100]	Block 2 [0.100, 0.200]	Block 3 [0.200, 0.300]	Block 4 [0.300, 0.400]	Block 5 [0.400, 0.600]	Block 6 [0.600, 0.771]
	Two-Sample Test of Means: Significance Level $= 0.01$ $\lvert T \rvert$ **Statistic**					
Parents' Region of Birth:						
- (Ref: Both parents are born in U.S.)						
- Mother is foreign-born (not Father)	0.365	0.619	0.927	1.010	1.021	0.872
- Father is foreign-born (not Mother)	1.065	1.048	0.062	0.234	2.010	1.655
- Both parents are foreign-born	0.257	1.355	0.114	0.330	0.351	0.283
Child household income: (Ref: $< \$10,000$)						
- between $\$10,000$ to $\$24,999$	0.825	0.236	0.071	0.751	0.944	1.678
- More than $\$25,000$	0.251	0.124	0.651	0.185	0.453	0.072
Parents' Educational Backgrounds:						
- (Ref: Mother's education: Less than HS)						
- Mother's education: H.S. diploma / GED	1.359	0.750	1.576	0.406	0.788	0.170
- Mother's education: some college	0.298	0.600	2.452	1.056	0.712	1.338
- Mother's education: bachelor and beyond	0.580	0.372	0.114	0.561	0.583	1.288
- Father's education: H.S. diploma / GED	1.327	1.009	1.296	0.197	1.176	0.844
- Father's education: some college	0.150	0.694	0.211	1.204	0.534	1.148
- Father's education: bachelor and beyond	0.000	0.000	0.754	1.010	0.844	0.762
Mother's education relative to father's:						
- (Ref: Same)						
- Father is less educated than Mother	0.918	1.537	2.330	0.758	1.720	0.818
- Father is more educated than Mother	0.111	0.247	0.392	0.703	0.762	0.442
Parents' labor force participation:						
- (Ref: Neither parents work)						
- Both parents work	1.013	0.201	0.695	0.619	0.285	1.181
- Only Mother works	0.613	0.708	0.754	0.000	0.583	0.000
- Only Father works	1.199	0.389	0.634	0.543	0.000	1.181

(Continued)

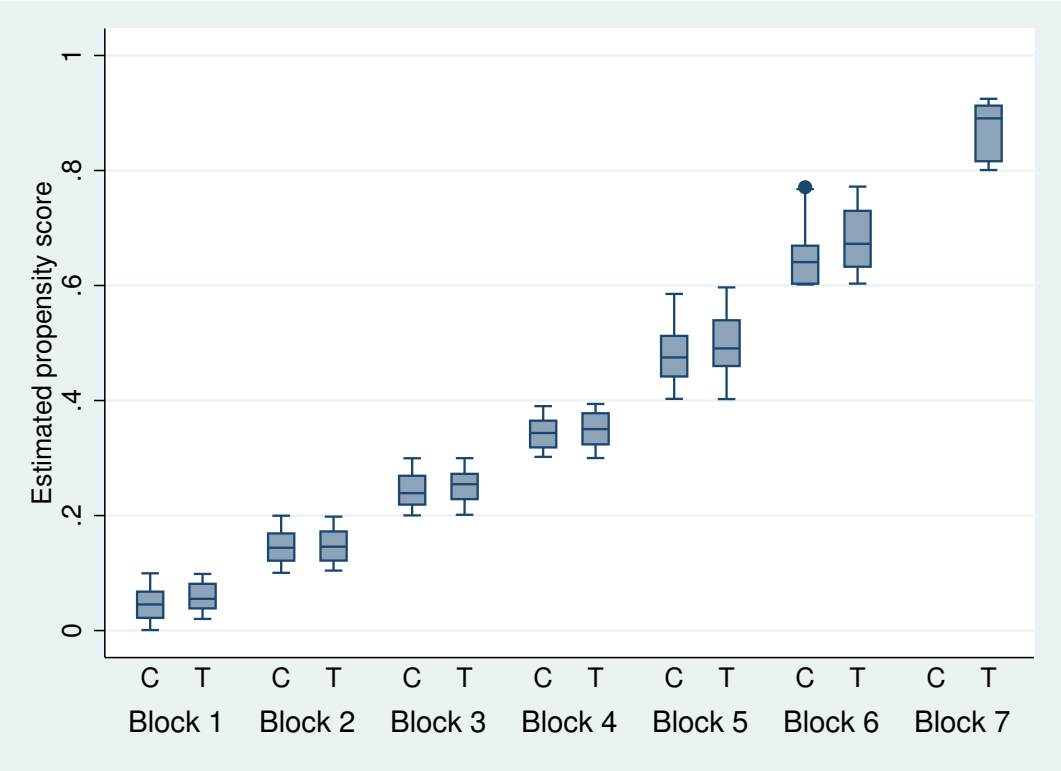
Appendix Table 1 **(Continued):** Test of Balancing Properties between the Control and Treatment Group (Two-Sample T-Test of Means): T-statistics Reported

Range of the Propensity Score	Block 1 $[0.020, 0.100]$	Block 2 $[0.100, 0.200]$	Block 3 $[0.200, 0.300]$	Block 4 $[0.300, 0.400]$	Block 5 $[0.400, 0.600]$	Block 6 $[0.600, 0.771]$
	Two-Sample Test of Means: Significance Level $= 0.01$ $\lvert T \rvert$ **Statistic**					
Mother's weekly hours of work	0.387	0.316	0.785	0.731	0.029	1.131
Father's weekly hours of work	0.630	1.448	0.939	1.196	0.547	2.813
Mother's labor inc. $>$ Father's labor inc.	0.636	0.708	0.141	0.476	0.000	0.872
Length of parents' relationship prior to preg.						
- (Ref: $>$ 2 yrs)						
- $\leq$ 6 months	0.480	0.767	0.990	0.352	0.556	1.288
- 6 months $\sim$ 1 year	0.369	1.135	0.904	1.457	1.434	0.872
- 1 year $\sim$ 2 years	1.034	0.501	0.367	1.031	0.253	0.561
Mother is catholic	0.498	0.317	0.392	1.195	0.000	1.510
Mother has no religious affiliation	0.006	1.255	1.757	0.124	0.322	0.186
Mother attends religious activities	0.690	0.533	1.578	0.747	0.740	0.175
(at least few times a week)						
Father suggested abortion during pregnancy	1.002	1.438	0.014	0.351	0.392	0.000
Maternal grandmother's education	1.065	0.678	0.404	0.007	0.556	0.277
(some college and beyond)						
Prenatal smoking (mother)	1.551	0.753	2.020	0.624	0.556	0.818
Prenatal drinking (mother)	0.728	0.642	1.280	0.061	0.000	0.000
Parents in visiting relationship (baseline)	1.223	1.826	1.499	0.330	0.000	0.796
Mother's PPVT score (Measured at Year 3)	0.786	0.169	0.163	0.703	0.804	0.481

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



Appendix Figure 1: Distribution of the Estimated Propensity Score



Appendix Figure 2: Box Plot of the Propensity Score Overlap (Relaxing the Common Support Condition)

Appendix Table 2: Effect of Parents' Marriage After Childbirth on Child PPVT Score Measured at Age 3 (Relaxing the Common Support Restriction)

	Matching Estimate	S.E.	*N* Treated	*N* Controls	% Matched Treated
Epanechnikov Kernel					
Bandwidth = 0.010	3.435*	1.666	198	853	100
Bandwidth = 0.005	3.449+	1.914	198	853	100
Gaussian Kernel	1.893	1.559	198	853	100
Radius					
Radius = 0.010	3.919*	1.353	187	815	94
Radius = 0.005	3.784*	1.430	182	750	92
N Treated (Total) = 198					
N Controls (Total) = 853					

Notes:

(1) Standard errors for all propensity score matching estimators obtained by bootstrap with 500 replications;

(2) Statistical significance reported at $* = 5\%$ level, $+ = 10\%$ level;

(3) Propensity score is re-estimated at each replication of the bootstrap procedure to account for uncertainty associated with the estimation of the propensity score;

(4) The propensity score is estimated using the probit model, using the following specification:

$Pr[M_i = 1] = F$[Parents' relationship status at baseline, 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 prior to pregnancy, father suggested abortion during pregnancy, mother's PPVT score, mother is catholic, mother has no religious affiliation, mother attends religious activities few times a week, prenatal smoking (mother), prenatal drinking (mother), household income (baseline), mother works (not father), father works (not mother), both parents work, mother's hours of work per week (baseline), father's hours of work per week (baseline), mother's labor income exceeds father's, maternal grandmother has some college education (or more), mother's state of residence (baseline)].

Appendix Table 3: Indirect Test of the Conditional Independence Assumption (CIA): Propensity Score Matching Estimates of the Effect of Parents' Marriage after Childbirth on Child Birth Weight

	Matching Estimate	S.E.	*N* Treated	*N* Controls	% Matched Treated
Epanechnikov Kernel					
Bandwidth = 0.010	0.004	2.161	190	762	100
Bandwidth = 0.005	0.857	2.299	190	762	100
Gaussian Kernel	0.261	1.651	190	762	100
Radius (Uniform Kernel)					
Radius = 0.010	−0.239	1.771	187	754	98
Radius = 0.005	0.477	1.958	181	731	95
N Treated (Total) = 190					
N Controls (Total) = 762					

Notes:

(1) Standard errors are obtained by bootstrap with 500 replications;

(2) 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;

(3) Estimated propensity score in region of common support $[0.02094842, 0.75192718]$, which is defined by the minimum estimated propensity score within the treatment group, and the maximum estimated propensity score within the control group;

(4) The propensity score is estimated using the probit model, using the following specification:

$Pr[M_i = 1] = F$[Parents' relationship status at childbirth, 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 prior to pregnancy, father suggested abortion during pregnancy, mother's PPVT score, mother is catholic, mother has no religious affiliation, mother attends religious activities few times a week, prenatal smoking (mother), prenatal drinking (mother), household income (baseline), mother works (not father), father works (not mother), both parents work, mother's hours of work per week (baseline), father's hours of work per week (baseline), mother's labor income exceeds father's, maternal grandmother has some college education (or more), mother's state of residence (baseline)].

Appendix: Matching Estimators

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, the *Kernel matching* matched all treated observations with a weighted average of all control observations with weights that are inversely proportional to the distance between the propensity scores of treated and controls. The *kernel matching estimator* is given by:

$$\tau^k = \frac{1}{N^T} \sum_{i \in T} \{Y_i^T - \frac{\sum_{j \in C} Y_j^C K(\frac{p_j - p_i}{h_n})}{\sum_{k \in C} K(\frac{p_k - p_i}{h_n})}\} \tag{5}$$

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:** $K(u) = \frac{3}{4}(1-u)^2$ for $|u| < 1$, and 0 otherwise
- **Gaussian:** $K(u) = \frac{1}{\sqrt{2\pi}} e^{-\frac{u^2}{2}}$ for all u
- **Uniform (Radius):** $K(u) = \frac{1}{2}$ for $|u| < 1$ and 0 otherwise

Under the standard conditions on the bandwidth and kernel,

$$\frac{\sum_{j \in C} Y_j^C K(\frac{p_j - p_i}{h_n})}{\sum_{k \in C} K(\frac{p_k - p_i}{h_n})} \tag{6}$$

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