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Changing Families: Family Relationships, Parental Decisions and Child Development

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Non-Technical Summary

A stable family environment is of crucial importance for child development. Nonmarital cohabitation, which tends to be a less stable family structure, has become increasingly prevalent in developed countries over the past few decades. An important question is to understand how the changing family structure influences child development.

There is a growing literature particularly in sociology that examines the correlation between family structure and child outcomes. However, the existing research still cannot robustly identify the causal effect of family structure. For instance, parents who form unstable families tend to have lower income and other unobserved characteristics such as lower ability. Particularly, those unavailable characteristics hinder a causal identification analysis. Furthermore, the framework used in this literature does not explicitly delineate the economic mechanisms through which family structure can affect children's skill formation.

We develop and estimate a tractable economic model using a large sample of disadvantaged families in the U.S.A to study the impact of family structure on children's cognitive and non-cognitive outcomes. Most importantly, combining our model with data, we are able to infer those unobserved characteristics and control them to reveal a robust causal effect of family structure on child development. We highlight the biological father's endogenous involvement with the child within and across relationships; the child's skill formation is influenced by the mother, biological father, and social father over time.

We find significant heterogeneity in the returns to paternal time investment by the skill endowment type of fathers. Investment made by high-ability fathers carry positive and significant returns, whereas investment made by low-ability fathers can generate negative returns. Interestingly, the return to father's time investment does not seem to vary by father's education level, highlighting the importance of identifying the distribution of unobserved ability of fathers. For non-cognitive outcomes, we find that paternal time spent with children reduces externalizing (aggressive and rule-breaking) behavior, more so by high-ability fathers and fathers cohabiting with the mother. Paternal time does not seem to affect internalizing (depressive, anxious, self-contained) behavior.

Our results suggest that family policies that incentivize (or disincentivize) mother and biological father cohabitation should pay attention to the quality of the fathers and potential social fathers in families,

because children benefit the most in terms of both cognitive and non-cognitive development by living with a high-quality father or social father.

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Abstract

We develop a tractable economic model to study the impact of family structure on children's cognitive and non-cognitive outcomes. Using panel data on both biological parents' behavior irrespective of subsequent relationship status, social fathers, and a set of exclusion restrictions, we identify the joint unobserved heterogeneity of the parents in our choice model, and examine child skill formation via a control function approach. Investments made by high-ability fathers carry positive and significant returns, whereas low-ability fathers may generate negative returns. Hence, policies that incentivize family formation should consider the quality of the fathers which mothers are cohabited with.

Keywords: Child Development, Family Structure, Parental Decisions, Cohabitation

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1 Introduction

Nonmarital cohabitation has become increasingly prevalent in the United States and many developed economies over the past few decades. Couples are shifting away from marriage toward becoming parents within a cohabiting union. Recent estimates show that about 40 percent of births in the U.S. occur outside of marriage, up from 28 percent in 1990 (Child Trends Data Bank, 2018).[1]

Cohabitation tends to be less stable than marriage, and accompanying the large increase in cohabitation is the large increase in the number of children experiencing transitions into single-parent families and stepfamilies. For instance, our estimates from the Fragile Families and Child Wellbeing Study indicate that, among cohabiting relationships at the time of a child's birth, about one-half dissolve by the time the child is five years old. Therefore, a salient feature of family environment in which the young generations grow up is the instability of family structure, or "turbulence" in family life (Cherlin, 2009).

To date, our understanding remains limited for the causal impact of family structure and family instability on child development.[2] A large early literature in sociology has examined the correlation between family structure indicators and child outcomes (e.g. McLanahan and Sandefur (2009); Brown (2004); Ribar et al. (2004)). More recent papers focus on family relationship transitions, concluding that children who experience multiple transitions in family structure fare worse developmentally than children raised in stable, two-parent families and maybe even stable, single-parent families (e.g. Fomby and Cherlin (2007); Lee and McLanahan (2015)). Although these studies suggest an important role of family structure in child development, the evidence typically cannot be interpreted as causal because family structure, relationship transitions and child outcomes may be associated with unobserved parental heterogeneity, e.g., parents (and their children) may differ systematically in their unobserved characteristics across different types of relationships. Furthermore, the framework used in this literature does not explicitly delineate the economic mechanisms through which family structure can affect children's skill formation.

In this paper, we develop a tractable economic model to study the impact of family structure

[1] Other developed countries have seen a similar increase in non-marital childbirth. For instance, in the United Kingdom, non-marital childbirth has increased significantly, from 9 percent of all live births in 1975 to 43 per cent in 2004, with three-fifths of these births to cohabiting parents (Office for National Statistics).

[2] As Lundberg, Pollak, and Stearns (2016) put it in their recent review paper, "credible estimates of the causal impacts of family structure patterns and trajectories on child outcomes still elude researchers".

on children's cognitive and non-cognitive outcomes. Our model starts from a focal child's birth and characterizes both biological parents' behavior *irrespective of subsequent relationship status*, including family relationship choice, labor supply, time investment in the child, welfare participation and child support in the case of separation. Our model contains two key features that help bridge the gap in this literature between sociology and economics (see below). First, it provides a comprehensive analytical framework for family structure by distinguishing the selection process between *biological* and *social (step)* parental relationships. We highlight the biological father's endogenous involvement with the child within and across relationships; the child's skill formation is influenced by the mother, biological father, and social father over time. Second, it quantifies the role of unobserved heterogeneity in explaining the observed differences in biological/social parental relationships and child outcomes. This is crucial for identifying the causal effect of family structure. Our analysis not only distinguishes between the heterogeneity of biological and social families but also considers a richer set of unobserved heterogeneity pertaining to each parent and their match quality, which is particularly important for children from unstable families and the disadvantaged population.

The model is estimated using longitudinal data from the Fragile Families and Child Wellbeing Study (FFCWS). The FFCWS follows a large sample of children from birth between 1998 and 2000 along with their parents. Oversampling births to unmarried parents, it contains a relatively large sample of children born in less stable families and covers the disadvantaged population in the U.S. One important feature of the data is that it continues to follow *both* the mother and the biological father even after they become separated. This allows us to empirically examine the joint distribution of parental choices conditional on family relationships and the dynamics of family relationships. To estimate the model, we construct panel data for both parents, using information from the baseline survey together with follow-up surveys when the focal child was 1, 3 and 5 years of age. The high-quality panel data from both biological parents inside and outside the relationship enables us to identify the heterogeneity of biological families. Together with a rich set of exclusion restrictions (including state-specific child-support rules, census tract-level characteristics, and the parents' early-life exposure to family relationships), we identify the *joint* distribution of unobserved heterogeneity of the father and mother.[3] Importantly, this unobserved heterogeneity is multi-dimensional and nonparametric, which

[3]For instance, as an exclusion restriction for child support, we use an index summarizing the state-specific strength in child support enforcement.

includes factors measuring both parents' skill endowments as well as their match quality.

We combine children's cognitive and noncognitive ability scores measured at age 5 with the estimated choice model to obtain the causal impact of parental and family inputs on child skill formation. Our empirical specifications assume that child development is a cumulative process based on the history of parental inputs and on innate ability. Following Chan and Liu (2018), we address the potential source of endogeneity bias via a control function approach, where the estimated choice model is used to predict parental unobserved characteristics. In particular, parental skill endowments (and hence the child endowment), conditional on their observed joint behavior in panel data, enter into the child ability production function as control functions, based on the premise that parental skill endowments are correlated with the child's unobserved endowment.

We find that maternal employment and quality time spent with children improve children's cognitive scores at age 5. Father's time inputs, *on average*, do not affect the cognitive skills of children in our sample. Yet there is significant heterogeneity in the returns to paternal time investment by the skill-endowment type of fathers. Investment made by high-ability fathers carry positive and significant returns, whereas investment made by low-ability fathers can generate negative returns. Interestingly, the return to father's time investment does not seem to vary by father's education level, highlighting the importance of identifying the distribution of "latent" ability of fathers. In terms of noncognitive outcomes, we find interesting patterns of asymmetry in the returns to paternal and maternal time investment. Paternal time spent with children reduces externalizing (aggressive and rule-breaking) behavior, more so by high-ability fathers and fathers cohabiting with the mother (and the child). Paternal time does not seem to affect internalizing (depressive, anxious, self-contained) behavior. On the contrary, maternal time spent with children mainly reduces internalizing behavior but has limited effects on externalizing behavior. We interpret these findings in Section 4.3.3, drawing on recent evidence from the developmental psychology literature.

We conduct several counterfactual scenarios, which use separation and union shocks to externally assign relationship status when the focal child is at age 1: (1) all mothers become single, (2) all mothers cohabit with the biological father, and (3) all mothers cohabit with a social father (regardless of the quality drawn). For example, in scenario 2, we find that cognitive outcome deteriorates but externalizing behavior improves. This is because cohabiting with a low-ability father can worsen the child's cognitive outcome, and the cohabitation can crowd out the prospect of mothers finding potentially high-quality social fathers, who have positive impacts on child development. Hence, family policies that incentivize family formation should also pay attention to the quality of the fathers which mothers are matched to.

Our paper relates to the recent literature viewing the production of child ability as determined by early-life parental inputs and innate skill endowment (Todd and Wolpin, 2003, 2007; Cunha and Heckman, 2008; Cunha, Heckman, and Schennach, 2010; Bernal and Keane, 2011). We extend this literature by separately estimating the return to inputs made by the mother, biological father, and social father on cognitive and noncognitive skills. Focusing only on cognitive skills and children from stable and married households, a recent paper by Del Boca, Flinn, and Wiswall (2014) finds that maternal time input is generally more productive than paternal time input. Although we find a small average effect of father's time input on cognitive ability (for children from the disadvantaged population), our findings instead suggest that the small average return masks the large amount of heterogeneity by father's skill endowment. The return from quality time spent with a "high-quality" father indeed can increase the child's cognitive test scores. Fathers also play a relatively more important role in improving noncognitive skills.

As in the literature, we correct for endogeneity bias resulting from unobserved child-specific endowment effects. Relative to studies controlling for family fixed effects (a scalar construct), our control function approach allows us to control for a richer set of unobserved heterogeneity pertaining to each parent and their match quality, which is particularly important for children from unstable families and the disadvantaged population.[4] The prevalence of family relationship transitions makes the family fixed effects difficult to interpret, as families are changing and so do their environments. Our empirical approach is related to Heckman and Navarro (2007); Heckman, Humphries, and Veramendi (2018); Fruehwirth, Navarro, and Takahashi (2016) and Attanasio, Cattan, Fitzsimons, Meghir, and Rubio-Codina (2020). Similar to our approach, in these papers there are common unobserved factors determining both choices and outcomes, and the empirical challenge is to identify the distribution of unobserved factors. Different from our parameterized choice model, the choice models in these papers

[4]For an example of using family fixed effects and comparing siblings within the family as sources of identification, see Rosenzweig and Wolpin (1994). Todd and Wolpin (2003) provide a comprehensive summary of a class of estimators used to "control" for permanent unobservable factors, making use of variation across observations within which the unobservable factor is assumed to be fixed (such as family fixed effects or children fixed effects). These fixed effects are one-dimensional. Instead, our unobserved heterogeneity is multi-dimensional, pertaining to each individual parent and their match quality, and allowing for unrestricted correlation between mother's and father's unobserved types.

are based on a generalized Roy model, which requires fewer explicit behavioral assumptions but places more restrictions in the form of unobserved heterogeneity. The control functions in our paper are predicted by the estimated economic model of both parents' joint behavior.

Closely related to our paper is Tartari (2015), who estimates a dynamic model of couples' behavior and their impact on cognitive development of the child using data from the NLSY79.[5] Tartari (2015) focuses on couples' decisions since marriage, following women from the date of their first marriage through their last interview, whereas we focus on parental decisions made by initially nonmarried parents within the first five years after child birth given the data structure. Her model is a fully specified dynamic structural model, where time-varying constraints as well as uncertainty about future wages, preferences, and child outcomes are explicitly specified. Indeed, one of the main goals of her paper is to use the model to assess how counterfactual policies that change parents' incentives to stay married affect the cognitive achievement of children. Our main goal, instead, is to correct for the endogeneity of inputs and family structure in the estimation of child ability production technology. To this end, we instead employ a sequential choice model, which is more reduced-form than Tartari (2015) but sufficiently flexible to capture joint parental behavior and identify the unobserved heterogeneity of the parents.[6] By formally including exclusion restrictions using state-specific policy rules and local area characteristics, as well as parents' early-life exposure to family relationships, our identification strategy is potentially more robust than using preexisting variations of parents' behavior in the data to identify the choice model parameters and control functions. Nevertheless, we acknowledge that one limitation of our model is that we cannot use it to study counterfactual policy reforms.[7]

This paper is organized as follows. Section 2 describes the FFCWS data and the sample, presents patterns of parental choices and family relationship transitions. In Section 3, we present the sequential choice model and discuss identification and estimation. Section 4 discusses the empirical specification

[5] Another related paper is Gayle, Golan, and Soytas (2015), who develop an infinite horizon dynastic model where adults choose fertility, labor supply, and time investment in children. Using data on two generations from the PSID, they estimate the model and use it to study the role of family structure in the large black-white achievement gap. Besides having a different focus (on analyzing the sources explaining the racial achievement gap), their paper does not study skill formation during early childhood.

[6] For instance, although the model in Tartari (2015) allows ex-spouses to choose how much to privately consume, how much to work, and how much time to devote to private leisure, information on husbands' wages and labor supply is only available up to when the marriage ends (a limitation of the NLSY relative to our data).

[7] Bernal (2008), Del Boca, Flinn, and Wiswall (2014), Chan and Liu (2018), Griffen (2019) and Mullins (2019) are additional recent contributions of using structural models of early-life parental inputs and childcare to estimate the child ability production function. These papers focus on stable families and do not model endogenous family relationship transitions and study their impact on child development. Except for Del Boca, Flinn, and Wiswall (2014), the father's role in child development is also not systematically examined.

and identification of the child ability production function, and reports the estimates. Section 5 uses the estimated child's ability production function and the choice model to analyze how shocks to family relationships affect child's ability, separating causal mechanisms from selection. Section 6 concludes.

2 Data and Descriptive Evidence

2.1 Data Sources and Sample Definition

We use longitudinal data from the Fragile Families and Child Wellbeing Study (FFCWS), a birth cohort panel that has followed nearly 5,000 children from birth (between 1998 and 2000) along with their parents. The sample includes children born in 20 large cities, a stratified random sample of 77 U.S. cities having populations of 200,000 or more. Cities were stratified into nine types of environments according to the generosity of welfare benefits, the degree of child support enforcement, and the strength of the local labor market. The study design includes baseline interviews conducted with recent mothers in the maternity wards of 75 hospitals. The FFCWS was designed to oversample births to unmarried parents.[8] The final sample consists of one quarter of births from married parents and the remaining three quarters born to unmarried parents.

At baseline, eligible mothers are asked to identify the biological father (referred to as "father" interchangeably) of the focal child, and fathers are interviewed in person during hospital visits or by telephone.[9] Follow-up surveys were conducted when the focal child was 1, 3, 5, 9 and 15 years of age. Each survey contains two separate questionnaires, a mother survey (answered by the mother of the focal child) and a father survey (answered by the biological father of the focal child).[10] Additional in-home surveys were conducted when the focal child was 3 and 5 years of age. These in-home surveys contain detailed measures of cognitive and non-cognitive skills.

[8] Quotas for the number of unmarried and married parents to be interviewed were set at each hospital, to mimic the hospital's 1996-7 unmarried birth rates. Interviewers attempted to complete interviews with all eligible couples until the quota for married parents was reached. Thereafter, they screened for marital status and only attempted to interview unmarried parents.

[9] Mother eligibility requirements were based on the need to interview both a mother and father of a child who would be residing with at least one of those parents over the next five years. For instance, mothers who were placing their baby for adoption and mothers who reported that the child's father was deceased were not eligible.

[10] Nearly all of the baseline mother interviews took place in person and over three-quarters of father interviews were in person—the remainder were interviewed over the telephone. Approximately 30 percent of mothers and 25 percent of fathers interviews at one-year were conducted over the phone; the remaining interviews were conducted in-person. About 98 percent of mothers and 95 percent of fathers were interviewed by phone at the three and five-year follow-up surveys.

One attractive feature of the FFCWS is that it aims to interview both biological parents in the hospital at the time of child birth, and follows *both* of them even after the family dissolves. This allows us, for instance, to observe father's labor supply and investment in children after separation (via child support and time investment). We believe that this is a unique feature when benchmarking against other survey data used in the literature. For instance, the Panel Study of Income Dynamics (PSID) only tracks people who have a "PSID gene", which means individuals who were interviewed in 1968 and their direct descendants.[11] In other words, only those people with the gene are continued to be tracked when split-off of households occurs. The Child Development Supplement of the PSID conducted in 1997 (CDS-I) includes an absent father survey which was meant to measure a rich set of absent fathers' behavior and interaction with child. However, the response rate for absent fathers is extremely low (at 22%). A follow-up study with the same children and families conducted in 2002–03 (CDS-II) no longer contains the absent father survey. Relative to the PSID and other large-scale panel datasets (e.g., the NLSY), a strength of the FFCWS is its ability to follow both parents along with the focal child. Also, FFCWS distinguishes between biological and social fathers.

Our sample consists of mothers and fathers who are unmarried in the baseline survey (about 75% of the FFCWS sample). We use information from the first four survey waves, including the baseline survey and surveys conducted when the focal child was 1, 3 and 5 years of age. We drop mothers surveyed from two cities (out of 20 cities) where the survey questionnaires are designed differently (13% observations dropped). We keep mothers who lived with the focal child in all surveys (3.5% of observations dropped) and completed all 4 waves of the mother survey (about 16% of mothers are dropped). Finally, we exclude a small number of mothers who experienced death to the father of the focal child or reported that father of the focal child is unknown in the first five years. The final sample is a balanced panel consisting of 2,240 mothers.

2.2 Definition and Measurement of Key Variables

Relationship status. We define a mother as cohabiting with the father if any of the following conditions is met: (1) she is married to the father and lives with him at least some of the time; (2)

[11] Suppose a woman has PSID gene, and she started to cohabit with a man in 1975, who was not interviewed in 1968 (i.e., no gene). Then, PSID tracks both individuals as long as they remain cohabited. But when they split into two households, only the woman continues to be tracked.

she is not married to the father but lives together with the father all or most of the time. A mother is cohabiting with a social father if she lives with the social father all or most of the time. A mother is single if she is cohabiting with neither the father nor the social father. All the survey questions drawn to define relationship status are from the mother survey. We are able to construct relationship status when the focal child was 0, 1, 3 and 5 years of age.

Labor supply and wages. Information on mother's labor supply and wages are available from mother surveys conducted when the focal child was 1, 3 and 5 years of age.[12] Weekly work hours of 35 or more are defined as full-time work, and work hours between 1 and 35 are defined as part-time work. If the frequency of reported earnings is hourly wage, we use the reported value directly. In all other cases, the hourly wage rate is calculated by dividing weekly earnings by weekly hours of work.[13]

We follow the same procedure to obtain father's labor supply and hourly wages from the fathers survey. For fathers we do not make a distinction between fulltime work and parttime work, so their labor supply decision is whether to work. Despite that the FFCWS made serious efforts to locate and interview the fathers, some attrition remains in the father survey. In our sample, 21% of fathers did not complete the baseline survey, with the attrition rates rising in each subsequent wave and reaching 29% in wave 5 survey. In order to obtain information on labor supply of the "missing" fathers, we rely on information provided by the mother. We define labor supply of these fathers as working if the mother reported the father's main activity at the time of the survey as working. We also impute wages for a small number of missing fathers who are employed and cohabit with the mother. More specifically, we divide household 'residual' income by 1750, where household residual income is obtained by subtracting total annual income of the mother from total annual household income.[14]

Quality time spent with child. To measure quality time spent with child, we mainly rely on information provided by the mother when the focal child was 1, 3 and 5 years of age. We choose mother survey as our primary source for parental time investment because our sample consists of children living primarily with the mother. The father survey contains an identical set of questions on quality time

[12]Labor supply information of the mother is not available in the baseline survey conducted in hospitals.

[13]Reported earnings are converted to weekly earnings depending on its timing unit of measurement. For instance, if the respondent reports earnings per month, we divide it by 4.3 to obtain the amount of weekly earnings.

[14]An additional 6% of fathers completed the father survey, reportedly cohabiting with the mother and working but have missing wages. For these fathers, we use the same procedure to impute their wages.

spent with child. For a small number of mothers who did not complete fathers' activities questions, we use information provided by the father to construct father time input. The mother survey records frequencies of different activities between the focal child and the parent in a typical week (separately for mother and father). Following Berger and McLanahan (2015), in the age-5 survey, engagement with the focal child was assessed by the number of days in a typical week that the mother (father) participated in each of eight activities with the child, including singing songs or nursery rhymes, reading stories, telling stories, playing inside with toys, telling the child he or she appreciated something the child did, taking the child on outings, playing outside in the yard with the child, and watching TV or a video with the child. In the age 3 survey, we use the first 6 activities as measure of parental engagement (excluding playing outside and watching TV). Engagement at age 1 is based on 4 activities, further excluding telling the child he or she appreciated something the child did and outing.

We measure quality time spent with child by first taking a simple average of weekly parental engagement activities by child's age. The lowest possible value is zero (no engagement) and the highest possible value is 7 (highest engagement). If a father has seen the child for no more than 5 days in a month, we regard the father as absent and their the quality time input as zero. We then split the weekly average quality time into two groups by the median (and by parent). For mother (father), we define high-level of quality time spent with child if the average weekly engagement activities is at least 5 (2) days.[15]

Child's cognitive and noncognitive ability. As measures of child's cognitive ability, we use the Peabody Picture Vocabulary Test (PPVT-III) which measures child's receptive vocabulary and verbal ability. The PPVT aims at measuring the child's listening comprehension for the spoken words in standard English. Children are provided with several pictures and asked to identify the one which best represents the word orally presented (a Spanish version - Test de Vocabulario en Imagenes Peabody, TVIP - is used for Spanish speaking children at age 3). The PPVT was administered in person at the respondent's residence as part of the in-home surveys conducted when the focal child was at age 3 and age 5. The sample includes focal children whose mothers/caretakers had given permission to a home

[15]We measure father and mother engagement with the child based on the same set of activities at each age. There may be some gender-specific roles in parenting, such as mother sings more to the child but father plays more with child outside. The overall set of activities, however, include activities suitable for both parents.

visit for an assessment.[16] Children with missing test scores (and their parents) are included in our sample for estimating the choice model. In the estimation of skill production function, we only include children with nonmissing age-3 and age-5 PPVT scores. The PPVT scores we use are standardized on a nationally representative sample of children.

Noncognitive abilities of the children are assessed by the Internalizing and Externalizing Behavior Problems subscales of the Child Behavior Checklist (CBCL). The CBCL is a commonly used measure of children's behavior problems. It is completed by the adult respondent to the survey, typically the child's mother, and can be administered by telephone. Our internalizing behavioral scores are derived from all itemized questions that measure anxious/depressed and withdrawn behaviours. The list of variables which are included in internalizing and externalizing behaviours is shown in Appendix Tables A1 (age-3 measures) and A2 (age-5 measures). In the age 3 (5) survey, there are 25 (22) questions measuring internalizing behaviours. Each question has the value 0 (not true), 1 (somewhat) or 2 (very true) which show the intensity of the child's behavior. Our internalizing score shows the mean of child's behavioral intensity, defined by the sum of the intensity from all related sub-variables divided by the number of related questions. Our externalizing behavioral scores are derived from all itemized questions that measure aggressive and destructive behaviours. Similar to the internalizing score, we construct the externalizing score by taking the average of all the questions measuring the intensity of externalizing behaviors. In the age 3 (5) survey, there are 22 (30) questions measuring externalizing behaviours.

Child support. For child support, we use information primarily from the father survey. A father is defined as paying for child support if the following three criterion are satisfied: (1) he is not cohabiting with the mother; (2) there is a legal agreement or child support order that requires him to provide financial support to the focal child; (3) he pays a positive amount of the legally agreed amount in the past 12 months since the survey date. For fathers who did not complete the father survey, we derive the same criterion from the mother survey.

Conditional on the father paying child support, we model the amount of child support payment

[16] In the entire FFCWS sample, about 2,300 (2,364) children had given permission for home visit for an assessment at age 3 (5) survey, out of 4,140 (4,055) mothers completing the wave 3 (5) survey. This translates into a test score availability rate at just under 60%. Note that around 10% of children completed the home visit survey but did not have the PPVT/TVIP scores because the child or the mother or both refused to participate in these tests or the tests could not be administered completely due to some irregularities.

as a fraction of fathers' labor income. We follow Pirog, Klotz, and Byers (1998) to compute the legal child support amount as a fraction of fathers' income, by state. The National Center for State Courts (NCSC) computed child support orders for every state using each state's child support guideline. The calculations were based on a scenario describing a family and its circumstances at five different income levels of the father and mother of a household (Munsterman, 1990). We focus on the average of the second and third scenario as the average household income in our sample is relatively low (Case B and C).[17] The fraction is computed assuming that the father and mother have two children together. For 1-child families, we scale the child support payment by 70%, which is the average 1-child CS amount as a proportion of 2-child CS amount.[18]

When estimating the choice model, we also use the state-specific Child Support Enforcement index constructed by Huang, Garfinkel, and Waldfogel (2004). The CSE index captures the strength of a state's CSE–it is a comprehensive measure of state child support legislation, expenditures, and implementation ability. The legislative component measures the vigor of state child support legislation, such as steps for establishing paternity, obtaining an award, and collecting child support payments. The expenditure component measures per capita child support expenditure. The state's CSE implementation ability is measured by child support collection rate, amount, and effectiveness. For details of the construction of this index, we refer to Huang, Garfinkel, and Waldfogel (2004). We use the 1999 CSE index, with a mean of 0.0098 and std of 0.0063 among the 15 states included in our sample.

Welfare program participation. A mother is defined as participating in TANF program if she received income from TANF in the past 12 months preceding to the time of the survey.

Census tract information. In estimating the choice model, we also use Census tract-level contextual data that are merged with the FFCWS based on the residence of respondents at the baseline survey. In particular, to control for economic conditions, data on the local unemployment rate and median household income are obtained from the 2000 census. As a proxy for the quality of males in the marriage market, we use proportion of population (age 25 and above) with bachelor's or higher degree

[17] Out of the 15 states in our data, 5 of them use percentage of income model (IL, MA, TN, TX, WI). For these states, the fraction of child support is computed by the predicted child support amount divided by the father's income. For the remaining states, the fraction of child support is given by the predicted child support amount divided by the father and mother's joint income.

[18] In Wisconsin, the 1-child CS amount as a proportion of 2-child CS amount is close to 70 percent (17% divided by 25% = 68%). See Chapter 8 of Ways and Committee (2004).

from the 2000 census.

2.3 Descriptive Evidence

Table 2 reports summary statistics on relationship status and choices made by mother and father, by child's age. In the first 5 years since child's birth, there is a large decline in the proportion of mothers cohabiting with fathers (M-B), from 47.7 percent at child's birth (age 0) to 33 percent at age 5. The decline in cohabitation with fathers is accompanied by a steady rise in the fraction of mothers cohabiting with a social father (M-S), where there is a 18.5 percentage points rise over this period. The proportion of single mothers only declines slightly. Among mothers, the fulltime employment rate is 40 percent at age 1. By age 5, the fulltime employment rate has increased to 46 percent. Over the same period, we find a decline in welfare program participation, with TANF use decreasing from 31.5 percent to 22 percent. Father's employment rate is relatively stable between child's age 1 and 5. The fraction of non-cohabiting fathers making child support payment rises from 19.7 percent at age 1 to over 30 percent at age 5.

The FFCWS is panel dataset that follows both mother and father regardless of their relationship status and also distinguishes between biological and social fathers. Exploiting these feature of the data, in Table 3 we report dynamics of family relationships, demonstrating high degree of family instability in the first five years since child's birth. Although the overall proportion of single mothers remains stable over the first five years (as reported in Table 2), the transition rates out of and into single mothers between two consecutive survey waves are in fact very high. For instance, from age 0 to 1, 22.8 percent of single mothers became cohabiting with father (M-B); 27.5 percent of M-B relationship ended leaving mothers being single. Transition rates between subsequent waves show similar patterns, with about one quarter of mothers in a M-B relationship becoming single and slightly over one quarter of single mothers beginning to cohabit with either the father or a social father. Single mothers moving to cohabit with a social father became increasingly common over time. Yet relationship with a social father is the least stable: 50.4 percent (36.4 percent) of mothers cohabiting with a social father at age 1 (3) ends up being single at age 3 (5). As discussed below, father's high-level quality time investment is even lower when the mother cohabits with a social father.

Figure 1 examines parental employment, quality-time spent with children and outcomes conditional on relationship status, using data from age-1, 3 and 5 surveys. We find that mothers' employment and time investment in children are relatively invariant to relationship status, whereas father's choices vary more by relationship status (first row of Figure 1). For instance, there is a 50 percentage points gap in the likelihood of spending high-level quality time with children between cohabiting and non-cohabiting fathers, suggesting that family instability is associated with large changes in father's quality time spent with child.

The second row of Figure 1 reports the joint distribution of mother and father's decisions by relationship status. Regardless of relationship status, it is most common for both father and mother to work (figure to the left). Therefore, our sample of families appears to differ from typical U.S. families in which father specializes in market work and mother specializes in household work. In fact, families in which only father works accounts for only one-third of the cohabiting families.

The joint distribution of mother and father time investment reveals additional interesting patterns. In M-B families, it is most common for both parents to spend high-level quality time with children (close to half of the M-B families), followed by only the father spending high-level quality time with children. In only 10 percent of M-B families we find that neither parents invest quality time with children.[19] However, after the father and mother are separated, the proportion of children without any high-level quality time investment (from either parent) more than triples. The fraction of mothers investing high-level quality time alone also increases after mother-father separation, yet such increase is not sufficient to compensate the decline in father investment. Therefore, children in non-cohabiting families experience different types of time inputs relative to children in cohabiting families; the former are more likely to spend high-level quality time only with the mother or not have any high-level quality time from parents at all.

The final row of Figure 1 compares log wage and log PPVT test score by relationship status. Mothers and fathers in a M-B relationship earn higher hourly wages on average than those in other relationship types. This wage difference may reflect endogenous selection into relationship status. For instance, a high-wage woman is more likely to have a partner with a higher income and their cohabiting relationship may be more stable. Examining mean children's outcomes by family relationship status at age 5, we

[19]Recall that we define high-level quality time investment as a discrete variable, separating time investment into low and high where the cutoff is defined at the median time investment separately by mother and father. Our definition therefore mechanically restricts that the overall proportion of high time investment to be 0.5 for both mothers and fathers.

find that the average difference in log PPVT score at age 5 between children from M-B families and those from single families is 0.02 (i.e., 4.53-4.51=0.02), which is about 0.12 standard deviations (sd). This test score gap is significantly smaller when compared to the test score gap by mother's education. For instance, the average difference in log PPVT score between the children of college-educated and non-college educated mother is 0.08 (0.48 sd). Relative to children from single mother families, children of M-B families achieve better noncognitive outcomes, particularly in externalizing scores. The average externalizing scores of M-B children are 0.056 point (0.12 sd) less than the average externalizing scores of single mothers, which is almost the same as the score gap between children of college-educated and noncollege-educated mothers (at 0.061). Differences in children's ability scores by family relationship status can be due to multiple and potentially competing factors, including endogenous relationship selection. In order to understand the relative importance of different factors affecting family structure and child's skill development, we next introduce an economic model of parental choices before taking the model to the data.

3 Model

3.1 Relationships

We assume that time is discrete and model the decisions by the biological parental pair starting from the birth of the focal child (period $t = 0$). Each period t consists of two decision subperiods $\tau = 1, 2$. The first subperiod is reserved for the biological father (B; referred to as "father" interchangeably). The second subperiod is reserved for the mother (M). The model distinguishes the following relationships:[20]

Relationship status	$\tau = 1$	$\tau = 2$
Single (M)	[B]	M
Cohabited with the father (M-B)	B	M
Cohabited with a social/step father (M-S)	[B]	M

Table 1: Relationship Status and Players in Each Subperiod

[20]Given that we only observe the joint distribution of outcomes of B and M in each period, there is no a priori reason for why B moves first. Although the ordering changes the spousal interaction, which may affect the joint distribution, a full characterization of the joint distribution is beyond the scope of our paper; we focus on using the panel nature of the data to pin down the unobserved heterogeneity of B and M. In addition, as is more evident in the choice model below, it is more natural to assume B moves first, e.g., B's child support payment determines the maximum welfare benefit amount that M can receive, and M does not necessarily tell B whether she is on welfare or not.

A key feature of the model is that it distinguishes between biological and social/step fathers. The notation [B] means that the biological father is not cohabited with the mother but he still makes a decision on relevant choices in $\tau = 1$.[21] Although the social father does not make decisions, he is endogenously matched with the mother (see the selection model below). There are two relationship state variables for the mother in period t:

- B_t=1 if cohabited with the biological father, =0 otherwise.
- S_t=1 if cohabited with a social father, =0 otherwise.

Therefore $(B_t = 0, S_t = 0)$ if M is single, $(B_t = 1, S_t = 0)$ if M is cohabited with the father, and $(B_t = 0, S_t = 1)$ if M is cohabited with a social father. We assume that B_t and S_t remain unchanged in period t and the relationship status is updated between time periods only. Reflecting the data, the relationship status in the initial period $t = 0$ is either single $(B_0 = 0, S_0 = 0)$ or M-B $(B_0 = 1, S_0 = 0)$, which is endogenous (see Section 3.5). We assume that B_t and S_t are common knowledge between the father and the mother.

We assume that the mother makes the relationship choice in period t, which changes the relationship status at the beginning of period $t + 1$. We use lowercase letters b_t, s_t to denote choices: the law of motion is $(B_{t+1}, S_{t+1}) = (b_t, s_t)$. If the relationship status is single or M-B, the mother can choose single, M-B, or M-S. If the relationship status is M-S, the mother can choose single or M-S.[22] The mother can re-cohabit with the father after they separate.

The distinction between biological and social fathers complicates the analysis in that when choices are made, the heterogeneity of *both* the biological and social fathers are taken into account (in combination with the mother's own heterogeneity). This heterogeneity is the key source of selection in our model and is characterized as follows. We assume the biological father-mother pair is heterogeneous in their skill endowments and the "natural" affinity/bond (or "match quality") between them – captured by unobserved types (j), which are assumed to be time-invariant and known to both parties in all stages of the model. For example, a pair could consist of a father with low skill endowment, a mother with high skill endowment, and a low degree of affinity/bond between them. This pair would be more

[21] Only a few mothers report at wave 0 that she does not know the whereabouts of the biological father. We drop them from the sample.

[22] In the data, fewer than 10 families switch directly from M-S to M-B between consecutive periods. For simplicity, they are recoded to switch from M-S to single.

likely to appear in the data as a short M-B relationship, or even without cohabitation throughout, with the father having lower average earnings (after accounting for selection into work) than the mother.

The matching technology, heterogeneity and selection regarding social fathers are described as follows. When the relationship status is single or M-B, the mother at the beginning of $\tau = 2$ makes an i.i.d. draw of a candidate social father whose skill endowment type (q, proxied by education) is a function of the mother's observed characteristics and unobserved skill endowment. For example, a high-skilled mother may be more likely to draw a high-skilled social father. The mother's tendency to choose a M-S relationship at $\tau = 2$ depends on this *realized* candidate type as well as the mother's observed characteristics and unobserved skill endowment. For example, the mother may prefer to choose M-S if she draws a high-skilled as opposed to low-skilled social father. If the relationship status is M-S, the mother takes the cohabiting social father's skill endowment type as given, and makes her relationship choice at $\tau = 2$ accordingly. In summary, the mother's relationship decision involves comparing the perceived values of choosing single, M-B and M-S, all of which are heterogeneous as described above.

In addition to B_t and S_t, we use two additional state variables to keep track of the evolution of the relationship: (1) Q_t: the candidate/cohabiting social father's type, and (2) E_t: a dummy variable equalling one if the biological parents have ever cohabited between $t = 0$ and the current period, zero otherwise.[23]

3.2 Child abilities

Child ability, $A_\cdot$, evolves across subperiods following each biological parent's actions and the presence/absence of the social father. We use $A_{t(\tau=1)}$ and $A_{t(\tau=2)}$ to denote the ability at the *beginning* of subperiod 1 and 2, respectively, in period t. Let A_t be the ability at the end of period t, which is also the end of subperiod 2 following the mother's actions and the presence/absence of the social father. It is carried over to the next period as $A_{t+1(\tau=1)} = A_t$.

We assume that the child's initial ability endowment is $A_{0(\tau=1)} = \gamma_{c0} + \mu_{cj}$ where the subscript j reflects the heterogeneity of biological father-mother type j. This innate μ_{cj} is most naturally interpreted as a weighted function of both biological parents' skill endowments alongside other factors (see the control function approach below). To simplify the empirical analysis, we assume $A_{1(\tau=1)} = A_{0(\tau=1)}$,

[23] The current model assumes that the biological father does not act on the cohabiting social father's type, but it can be readily extended to incorporate this feature.

i.e., we only focus on the technological returns of parental involvement from age 1 onwards. We consider cognitive and noncognitive abilities separately.

Following the father's action in subperiod 1, the child's ability at the start of subperiod 2 may evolve according to the following production function:[24]

$$A_{t(\tau=2)} = A_{t(\tau=1)} + \gamma_B^B B_t + \gamma_m^B m_t^B + \gamma_{mB}^B B_t m_t^B + \gamma_y^B y_t^B \tag{1}$$

where m_t^B and y_t^B are father's time and monetary investment on the child. γ_B^B captures the return from the father residing with the mother (and hence the child), γ_m^B captures the technological returns of the father's time input when the father is not cohabiting with the mother, γ_{mB}^B captures the differential returns of the father's time input when the father cohabits with the mother, and γ_y^B captures the reduced-form technological return of the father's money input.

Following the mother's action in subperiod 2, the child's ability may further evolve according to the following benchmark case:

$$A_t = A_{t(\tau=2)} + \gamma_m^M m_t^M + \gamma_y^M y_t^M + (\gamma_S + \gamma_{SQ} Q_t) S_t + \gamma_A, \tag{2}$$

where m_t^M and y_t^M are mother's time and monetary investment on the child. γ_m^M captures the technological return of the mother's time input, γ_y^M captures the reduced-form technological return of her money input, γ_S captures the effect of presence of the social father, γ_{SQ} captures heterogeneity in returns by the social father's quality, and γ_A captures the "natural" growth of the child's ability over time.[25]

As is evident from the child's ability production functions (equations (1) and (2)), child's ability can be influenced by mother and father's time inputs, labor supply (affecting income), family relationship status and the presence and quality of social father. These are endogenous decisions which are potentially driven by the heterogeneity of biological father-mother type. In the rest of this section, we

[24] A benchmark example is given in equations (1) and (2) below. Additional specifications of the production function are discussed in Section 4.

[25] This benchmark does not include shocks to A. In a general model, realizations of shocks (or perceived shocks), in combination with the preference structure of parents for child development, may affect parental investment decisions. This can generate complex parental investment dynamics; for example, a child subject to a large negative shock (i.e., low realized A) may induce parents to intensify their involvement. Our choice model abstracts away from this dynamics, as we assume that parental utilities are linear in child's perceived ability, and, consequently, any shocks to A will not change parental choices materially.

specify how these endogenous choices are made in a setting where individuals maximize their utilities, explicitly accounting for the mother's and the father's unobserved heterogeneity.

3.3 Biological father (B)

The father acts at $\tau = 1$ given the state variables B_t, S_t, $A_{t(\tau=1)}$ and realizations of his preference and wage shocks. The choice variables are:

- h_t^B: no work (=0), full-time work (=1).
- m_t^B: "quality" time spent with child (low (=0), high (=1)).
- $p_{CS,t}$: whether to pay child support. This is relevant only when $B_t = 0$ (i.e., the father is not cohabited with the mother).

We use the following specification as an approximation to the perceived value of each alternative:[26]

$$\begin{aligned}\bar{u}_t^B &:= y_t^B + \alpha_A^B A_{t(\tau=2)} + \alpha_B^B B_t + \tilde{\alpha}_h^B h_t^B + \tilde{\alpha}_m^B m_t^B + \tilde{\alpha}_{CS} p_{CS,t} \\ &\quad + \alpha_{hm}^B h_t^B m_t^B + \alpha_{hB}^B h_t^B B_t + \alpha_{mB}^B m_t^B B_t + \alpha_{mS}^B m_t^B S_t. \end{aligned} \tag{3}$$

where $\tilde{}$ indicates that the parameter is a linear function of observed covariates and exclusion restrictions; for example, $\tilde{\alpha}_{CS} := \boldsymbol{x}_{CS}^B \boldsymbol{\beta}_{CS}$ where $\mathbf{x}_{CS}$ includes the unit constant, the father's education and the child support enforcement index of the state that the father resides in. A full discussion of the model's covariates and exclusion restrictions is in Section 3.6.

Some interaction terms are included to capture potential differences in choice patterns along key dimensions. For example, α_{hm}^B may reflect an implicit tradeoff via a time constraint between work and quality time; α_{hB}^B, α_{mB}^B and α_{mS}^B may reflect optimal combinations of work and quality time in different types of relationships.

[26] For identification, the coefficient on income y_t^B, which enters linearly into the model, is normalized to one. We do not have clear exogenous variations of nonlabor income in the data and hence do not attempt to identify the income effect. In addition, although we abstract away from borrowing and saving, consumption of B and M are not explicitly modeled.

The budget constraint and log wage equation are:

$$y_t^B = w_t^B h_t^B (1 - \tilde{\phi}_{CS} p_{CS,t}) \qquad \text{if} \quad B_t = 0, \tag{4}$$

$$y_t^B = w_t^B h_t^B \qquad \text{if} \quad B_t = 1, \tag{5}$$

$$\ln w_t^B = \tilde{\alpha}_w^B + \mu_{wj}^B + \epsilon_{wt}^B. \tag{6}$$

where $\tilde{\phi}_{CS}$ is computed from the child support rule in the father's state of residence (see the Data section).[27] The father's unobserved skill endowment is given by μ_{wj}^B, which has subscript j reflecting heterogeneity by biological family type j. ϵ_{wt}^B is an i.i.d. normally distributed wage shock with standard deviation σ_w^B.

The choice set differs by the time period and relationship status. At $t = 0$, we assume that the father makes a binary decision on work only. In subsequent periods, the father faces four alternatives (work and investment) if the relationship status is M-B, and he faces all eight alternatives (work, investment and child support) if the relationship status is single or M-S. Let k be an index representation of the father's actions. The perceived value of alternative k is given by $u_{jkt}^B := \bar{u}_{jt}^B(k) + \epsilon_{ukt}^B$ where ϵ_{ukt}^B is an alternative-specific preference shock. The vector of preference shocks is denoted by $\boldsymbol{\epsilon}_{ut}^B$, and is assumed to follow an i.i.d. extreme value distribution with standard deviations at $(\pi/\sqrt{6})\sigma_u^B$, where $\pi/\sqrt{6} \approx 1.2825$ is a normalization constant.[28] In summary, the father's choices are generated by maximizing (3) subject to (4)-(6) and realization of shocks; his choices are driven by the state variables and heterogeneity terms he faces.

Limitations of the Choice Model. The choice model is relatively flexible but has limitations. If individuals are forward-looking, the perceived continuation values (i.e., the expected future value embedded in each alternative) may enter into the perceived values in a more complicated manner than what is specified in equation (3). For example, a child with a low realized $A_{t(\tau=1)}$ may induce parents to intensify their investment due to a higher future marginal value of investment. Including more interaction terms with state variables may mitigate this issue, but run the risk of data-fitting without theoretical justification. Relatedly, equation (3) does not explicitly account for the mother's

[27] We assume that the child support reduces income proportionally. See Lerman and Sorenson (2003) for discussions. In reality, the child support amount is more complicated; it may be more closely related to the father's average income and is not always routinely updated.

[28] Throughout the paper, all shocks are assumed orthogonal to each other unless otherwise stated.

response to the father's actions. For example, the father may keep working or spending time with the child because he anticipates that the mother may break up the relationship otherwise (resulting in child support payments etc.). Such incentives are assumed to be adequately captured by the work and investment preference parameters in equation (3). Yet spousal interactions may result in a more complicated joint distribution of spousal outcomes beyond what is predicted by the current model. Finally, the parameters in the choice model, which encapsulate both the utility flow and perceived continuation values, are not necessarily invariant to counterfactual policy scenarios. For example, increasing child support payments may affect the father's incentive to maintain the relationship via changing the perceived continuation values of being single, but this analysis is not possible in the current model. We will elaborate on the limitations in the next subsection. Although the choice model has these limitations, it takes the unobserved heterogeneity of the biological and social parents seriously and allows for selection along this key dimension. It is also able to decompose the observed outcomes into various components explained by observable and unobservable characteristics.

Parameter Normalization. Suppose the father perceives the child's ability to evolve according to equation (1). Substituting equation (1) into equation (3), and because $A_{t(\tau=1)}$ shifts the perceived value of each alternative by an equal amount, the coefficient α_A^B is not identified. We normalize $\alpha_A^B = 0$, but it does *not* imply that fathers do not care about the child's ability. The time investment parameter $\tilde{\alpha}_m^B$ can be shown to have a mapping to the preference for child ability under explicit functional form conditions for a fully dynamic structural model (see Mullins (2019) for details). Similarly, the relationship status shifts the perceived value of each alternative by an equal amount ($\alpha_B^B B_t$). (Note: Whether M cohabits with S, S_t, does not enter the perceived value of B.) This term implicitly reflects the nonpecuniary and pecuniary benefits of the M-B relationship, the latter of which are based on the economies of scale from the relationship net of intra-household transfers between B and M. We normalize $\alpha_B^B = 0$.[29]

[29]This is subsumed into the perceived value of the relationship to M (as $\tilde{\alpha}_b$ in (9)). As discussed earlier, these perceived values are unlikely to be invariant to counterfactuals. For example, if the government increases child support payment, B will be more inclined to stay in the M-B relationship and even transfer more of his own income to M to maintain the relationship. Yet M may be more inclined to break up the relationship. See Sun (2008) for a discussion of this ambiguity. In our model it is more natural to assume that M makes the relationship choice – the child stays with M, and M may cohabit with B or S.

3.4 Mother (M)

At the beginning of $\tau = 2$, the mother faces state variables B_t, S_t, E_t, $A_{t(\tau=2)}$, and the father's actions at $\tau = 1$. If the mother is not cohabiting with a social father ($S_t = 0$), she makes an i.i.d. draw of a candidate social father with quality Q_t; otherwise she takes the cohabiting social father's quality as given:[30]

$$Q_t = \begin{cases} 1 & w.p. \quad \Phi(\tilde{\alpha}_Q + \beta_Q \mu^M_{wj}) \\ 0 & w.p. \quad 1 - \Phi(\tilde{\alpha}_Q + \beta_Q \mu^M_{wj}) \end{cases} \qquad \text{if} \quad S_t = 0, \tag{7}$$

$$Q_t = Q_{t-1} \qquad \text{if} \quad S_t = 1. \tag{8}$$

where $\Phi(\cdot)$ is the standard normal CDF, $\tilde{\cdot}$ indicates the parameter is a linear function of observed covariates and exclusion restrictions (see Section 3.6), and μ^M_{wj} is the mother's unobserved skill endowment (see wage equation below). If $\beta_Q > 0$, the matching technology is assortative in that high-ability mothers are more likely to draw high-ability social fathers. Once Q_t is determined, the mother's acts at $\tau = 2$ given realizations of her preference and wage shocks. The choice variables are:

- h^M_t, h^M_{Ft}: no work ($h^M_t = h^M_{Ft} = 0$), part-time work ($h^M_t = 1, h^M_{Ft} = 0$), full-time work ($h^M_t = h^M_{Ft} = 1$).[31]
- m^M_t: "quality" time spent with child (low (=0), high (=1)).
- $p_{WF,t}$: no welfare (=0), welfare (=1).
- b_t, s_t: become single, cohabit with B, cohabit with S next period. (The relationship status next period becomes $B_{t+1} = b_t$ and $S_{t+1} = s_t$.)

[30] That is, the relationship-specific capital is destroyed when M and S separate.

[31] Part-time and full-time work in the model are assumed to be 20 and 40 hours per week, respectively.

We use the following specification as an approximation to the perceived value of each alternative:[32]

$$\begin{aligned}\bar{u}_{jt}^{M} :=\ & y_t^M + \alpha_A^M A_t + \alpha_B^M B_t + \alpha_S^M S_t + \tilde{\alpha}_h^M h_t^M + \alpha_{hF}^M h_{Ft}^M + \tilde{\alpha}_m^M m_t^M + \tilde{\alpha}_{WF} p_{WF,t} \\ & + \alpha_{hm}^M h_t^M m_t^M + \alpha_{hBS}^M h_t^M (B_t + S_t) + \alpha_{mBS}^M m_t^M (B_t + S_t) \\ & + (\tilde{\alpha}_b + \mu_{bj}) b_t + (\tilde{\alpha}_s + \beta_{sw} \mu_{wj}^M) s_t + \alpha_{sQ} s_t Q_t \\ & + \alpha_{bB} b_t B_t + \alpha_{sS} s_t S_t + \alpha_{sB} s_t B_t + \alpha_{sE} s_t E_t (1 - B_t - S_t).\end{aligned} \tag{9}$$

We first discuss the parameters for relationship choice (last two lines of equation (9)), which are of particular interest. The parameters in the first two lines of equation (9) are deferred to the end of this subsection.

The perceived value of the M-B relationship is captured by $\tilde{\alpha}_b$ and μ_{bj}, the latter of which is heterogeneous by unobserved biological family type j. This perceived value reflects the "natural" affinity/bond between M and B, and the implicit pecuniary benefits (e.g., economies of scale and transfer arrangements) of the M-B relationship. This perceived value is determined by the permanent observed and unobserved socioeconomic conditions of M and B (including their skill endowments) and is assumed invariant to the transitory socioeconomic conditions of M and B.[33] As discussed in previous sections, this unobserved permanent heterogeneity is crucial for identifying the causal impact of family structure, and we leave the transitory conditions for future research.

The perceived value of the M-S relationship is mainly captured by $\tilde{\alpha}_s$ and $\beta_{sw}\mu_{wj}^M$, the latter of which is a linear function of M's unobserved skill endowment. If $\beta_{sw} < 0$, then high-ability mothers have lower perceived values of M-S relationships, e.g., they may be more selective in choosing social fathers and find M-S relationships less appealing than being single. In addition, the term $\alpha_{sQ} s_t Q_t$ captures the heterogeneity in perceived value of M-S relationship by the social father's quality, Q_t. If $\alpha_{sQ} > 0$, then an M-S relationship is more appealing to the mother when the social father has high quality as opposed to low quality. The matching technology in combination with the choice specification determine the endogeneity of the M-S relationship. Suppose we observe that mothers are seldom cohabited with

[32] Recall that the mother's relationship status is single if $B_t + S_t = 0$, and she is cohabiting with the biological/social father if $B_t + S_t = 1$.

[33] The latter rules out situations where, for example, B earns a smaller amount temporarily due to a transitory wage shock causing the M-B relationship to dissolve. To capture these situations we would need a more general model and higher-frequency data. The current data is able to identify the permanent unobserved heterogeneity in relationship values, but it may be too crude to capture intricate dynamics.

high-quality social fathers; without further information, we do not know whether it is due to a low probability of drawing high-quality social fathers (technology), or mothers being selective in choosing partners. Section 3.6 discusses relevant exclusion restrictions for identification of this selection problem.

The last line of equation (9) captures state dependence in perceived values for M-B and M-S relationships. For example, a relationship may persist once it is formed ($\alpha_{bB}, \alpha_{sS} > 0$); it may be less likely to switch directly from M-B to M-S ($\alpha_{sB} < 0$); it may be less likely for M to re-cohabit with B once they separate ($\alpha_{sE} > 0$).

M's log wage equation is:

$$\ln w_t^M = \tilde{\alpha}_w^M + \mu_{wj}^M + \epsilon_{wt}^M. \tag{10}$$

where μ_{wj}^M is her unobserved skill endowment (in biological family type j) and ϵ_{wt}^M is an i.i.d. normally distributed wage shock with sd σ_w^M.

M's budget constraint is affected by B's actions via child support and welfare rules. If $B_t = 0$ (single or M-S), she may receive welfare and/or child support:

$$y_t^M = w_t^M(h_t^M + h_{Ft}^M) + \tilde{\mathcal{B}}_{WF}[w_t^M(h_t^M + h_{Ft}^M)]p_{WF,t} + \tilde{\mathcal{B}}_{CS}[y_{CS,t}^B, \tilde{\mathcal{B}}_{WF}(\cdot)p_{WF,t}], \tag{11}$$

where $\tilde{\mathcal{B}}_{WF}[.]$ is the welfare benefit formula and $\tilde{\mathcal{B}}_{CS}[.]$ is the child support formula *net of* the welfare benefit received.[34] When M is not on welfare, her child support amount equals the gross child support payment by B ($y_{CS,t}^B := w_t^B \tilde{\phi}_{CS} h_t^B p_{CS,t}$). Importantly, states differ in the child support "pass-through" policy: when M is on welfare, the child support payment by B may be retained by the state and not passed through to M. Hence the child support payment can generate complicated incentives on M's welfare participation and labour supply.[35] There are three broad categories of state rule when $p_{WF,t} = 1$: (1) No pass-through: $\tilde{\mathcal{B}}_{CS} = 0$, (2) Fixed-amount pass-through: $\tilde{\mathcal{B}}_{CS} = \tilde{b}_{CS} > 0$, and (3) Variable-amount pass-through: $\tilde{\mathcal{B}}_{CS} = max\{y_{CS,t}^B - \tilde{\mathcal{B}}_{WF}(\cdot), 0\}$.

[34] Welfare rules are based more on the biological relationship than on cohabitation (see Moffitt, Phelan, and Winkler (2020) for details); we assume that the social father is outside the assistance unit and does not affect the welfare benefit.

[35] See Hu (1999) who examines the effect of child support and AFDC policy on women's labor supply and welfare participation. AFDC implements a fixed-amount pass-through policy of child support income. States are allowed to change this policy under TANF.

If $B_t = 1$ (M-B), M's budget constraint is:

$$y_t^M = w_t^M(h_t^M + h_{Ft}^M) + \tilde{\mathcal{B}}_{WF}[w_t^M(h_t^M + h_{Ft}^M) + y_t^B]p_{WF,t}, \tag{12}$$

where B's income (y_t^B) enters into the welfare benefit formula.[36] As discussed earlier, this budget constraint only captures M's explicit sources of income; other pecuniary benefits such as economies of scale and intra-household transfer arrangements are kept implicit in the parameters for the perceived value of the M-B relationship.[37] Also, M's behavior does not vary systematically with B's *transitory* economic conditions except via the welfare and child support benefit rules.

M's choice set differs by the time period and relationship status. At $t = 0$, we assume she makes a relationship choice only (three alternatives).[38] In subsequent periods, the mother faces 36 alternatives (work, investment, welfare and relationship choice (single, M-B, M-S)) if the relationship status is single or M-B, and she faces 24 alternatives (work, investment, welfare and relationship choice (single, M-S)) if the relationship status is M-S. The perceived value of alternative k is $u_{jkt}^M := \bar{u}_{jt}^M(k) + \epsilon_{ukt}^M$ where ϵ_{ukt}^M is an alternative-specific preference shock. The vector of preference shocks $\boldsymbol{\epsilon}_{ut}^M$ follows an i.i.d. extreme value distribution with sd at $(\pi/\sqrt{6})\sigma_u^M$. In summary, the mother's choices are generated by maximizing (9) subject to (10)-(12) and realization of shocks; her choices are driven by the state variables, B's actions (via child support and welfare rules), and heterogeneity terms she faces.

Remark. A few remarks are in order for the parameters in the first two lines of equation (9). Similar to the father's case, the coefficients α_A^M, α_B^M and α_S^M are not identified and are normalized to zero.[39] Parameters $\tilde{\alpha}_h^M$, α_{hF}^M, $\tilde{\alpha}_m^M$ and $\tilde{\alpha}_{WF}$ shift each key dimension of the mother's choice. Interaction terms are included to capture potential differences in choice patterns along key dimensions. For example, α_{hm}^M

[36] For simplicity, we assume that M makes the welfare participation decision. Two-parent families constitute a small proportion of families on welfare (less than 10% among all families on AFDC). See Hoynes et al. (1996) for a unitary household model of welfare participation in two-parent families. Our model assumes that welfare rules do not affect B's labor supply in M-B relationships. This may be more reasonable if income pooling is incomplete; for example, welfare benefits are received and spent by M and there is no gain for B.

[37] Although M tends to have more explicit income when the relationship status is single/M-S than M-B (see equations (11) and (12)), what matters for relationship choice is the expected future streams of income, which are kept implicit in the parameters for relationship choice as an approximation (see equation 9). This also implies that the parameters for relationship choice (e.g., $\tilde{\alpha}_b + \mu_{bj}$, $\tilde{\alpha}_s + \beta_{sw}\mu_{wj}^M$) are *not* invariant to counterfactuals that involve changing welfare and child support rules.

[38] We assume that she does not work nor receive welfare. This does not affect her relationship choice.

[39] Suppose the mother perceives the child's ability to evolve according to equation (2). Substitute equation (2) into equation (9). $A_{t(\tau=2)}$, B_t and S_t shift the perceived value of each alternative by an equal amount.

may reflect an implicit tradeoff via a time constraint between work and quality time; α^M_{hBS}, α^B_{mB} and α^M_{mBS} may reflect optimal combinations of work and quality time in different types of relationships. Overall, although we do not capture the intricate dynamics and responses to transitory socioeconomic conditions between the father and the mother, they interact via the budget constraint and their joint distribution of choices is allowed to differ systematically across different types of relationships and across different unobserved family types.

3.5 Unobserved Heterogeneity and Initial Conditions

Unobserved heterogeneity is a key source of selection in our model. It involves the joint distribution of heterogeneity of biological families and the heterogeneity of social fathers. These features are crucial for deriving control functions in the estimation of child ability production technology.

We first discuss the heterogeneity of a biological parental pair determined at $t = 0$ when the child is born. Let a type-j biological family ($j = 1, .., J$) be represented by the vector $(\mu^M_{wj}, \mu^B_{wj}, \mu_{bj})$, where μ^M_{wj}, μ^B_{wj} are the biological parents' skill endowment, and μ_{bj} is the "natural" affinity/bond between M and B. No functional form relationship is imposed among these components. We normalize the vector of a type-1 biological family to zero. The biological family's type is relevant in all periods of the model because even after the parents separate, the father may still engage with the mother and child, and they may re-cohabit later.

Selection into M-S relationships is governed by the matching technology that draws the social father's quality type, and the relationship choice given the realized quality type. As discussed in Section 3.4, both depend on the mother's skill endowment μ^B_{wj}, amongst other factors. For simplicity, we assume that there are two quality types ($q = 0, 1$) proxied by education: $q = 0$ denotes high school graduate or below, and $q = 1$ denotes at least some exposure to college.

The empirical analysis should also address the initial conditions problem that the relationship status at $t = 0$ (either single or M-B) is endogenous; namely, a biological family with high affinity/bond μ_{bj} is more likely to have already formed an M-B relationship at $t = 0$. One solution is to include an additional equation in which the probability of having $B_0 = 1$ is a function of μ_{bj}. We expect the coefficient on μ_{bj} to be positive. Another solution is to model B_0 as a flexible function of biological family type, for instance:

$$B_0 = \begin{cases} 1 & w.p. \quad \Phi(\tilde{\alpha}_{B0} + \sum_{j=2}^{J} \beta_{B0j} \mathbf{1}\{type = j\}) \\ 0 & w.p. \quad 1 - \Phi(\tilde{\alpha}_{B0} + \sum_{j=2}^{J} \beta_{B0j} \mathbf{1}\{type = j\}) \end{cases} \tag{13}$$

where $\tilde{}$ indicates that the parameter is a linear function of observed covariates and exclusion restrictions; $\mathbf{1}\{type = j\}$ is an indicator function equalling one if the biological family belongs to type j, zero otherwise. We expect the biological family types that have a high μ_{bj} to also have a high β_{B0j}. We adopt the second approach; therefore a biological family type is represented by the vector $(\mu_{wj}^{M}, \mu_{wj}^{B}, \mu_{bj}, \beta_{B0j})$. Although the biological family type is known to both M and B, it cannot be observed by the researcher. The probability that the biological family belongs to type j is denoted by π_j, where $\sum_{j=1}^{J} \pi_j = 1$. In the next section, we discuss how the full model is estimated with all heterogeneity and match quality terms added.

3.6 Estimation and Likelihood function

The model is estimated by the method of maximum likelihood. The likelihood function accounts for: (1) choices of both parents, (2) heterogeneity of biological families, (3) heterogeneity and selection of social fathers, (4) endogeneity of the initial relationship status, and (5) selection into work by each parent.

Table 4 summarizes the model's structure, covariates and exclusion restrictions. Due to our emphasis on the role of skill endowments, we focus on parental education as the key covariate (=0 if high school graduate or below, =1 if at least some exposure to college). The model has some natural asymmetries in its structure. B's education affects all his key dimensions of choice (work, investment, child support), his wage, initial relationship status, and M's preference for M-B relationship. M's education affects all her key dimensions of choice (work, investment, welfare, relationship), her wage, the initial relationship status, and the probability of drawing a high-quality social father. As discussed above, the biological family unobserved types enter (nonparametrically) into B and M's wage equations, initial relationship status, and M's preference for M-B relationship. M's unobserved skill endowment enters linearly into M's preference for M-S relationship and the probability of drawing a high-quality social father.

To facilitate identification, we include exclusion restrictions ("shifter" variables) in each key dimension of the model. The wave 0 survey contains information about parental relationship background such as: (1) how many years M has known B prior to the survey, (2) whether M lived with both of her biological parents at age 15, and (3) whether B lived with both of his biological parents at age 15. We assume all three variables shift M's preference for M-B relationship and the initial relationship status. Additionally, variable 2 shifts M's time investment and her preference for M-S relationship; variable 3 shifts B's time investment. We also construct several variables at the *census tract* level: (4) proportion of the aged 25+ population with a bachelor degree or above, (5) median household income, and (6) unemployment rate.[40] Variable 4 is assumed to shift the probability of drawing a high-quality social father (note: we have controlled for individual-level education). In a similar spirit to Keane and Moffitt (1998), we assume variable 5 shifts B and M's wages and variable 6 shifts B and M's work choice. The child support enforcement index enters as a shifter variable for B's child support choice. The other policy parameters enter into the budget constraint as described in Section 3.4. These exogenous sources of variation facilitate identification of the choice model parameters and control functions (see Section 4 for examples).

The likelihood function is constructed as follows. Consider biological family i in period $t = 0, 1, ..., \mathcal{T}$, where $\mathcal{T}$ is the last observed period in the data. If the observed relationship status is single or M-B (i.e., the M-S relationship variable $S_{it} = 0$), we observe B and M only. If the observed relationship status is M-S (i.e., $S_{it} = 1$), not only do we observe B and M but also the quality of S who is matched to M; in that case, we also assign subscript i to the matched S.

Conditional on B's wage w_{it}^B (observed for workers), state variables $\boldsymbol{S}_{it(\tau=1)} = (B_t, S_t, E_t)$, and biological family type j, let $\bar{u}_{ikt}^B(w_{it}^B, \boldsymbol{S}_{it(\tau=1)}, j)$ denote B's alternative-specific value to alternative $k \in \mathcal{C}_{it(\tau=1)}$ that is *exclusive* of his preference shock, where $\mathcal{C}_{it(\tau=1)}$ is the indexed representation of B's choice set. Due to the distributional assumption of the preference shock, B's choice probability is

$$P_{ikt}^B(w_{it}^B, \boldsymbol{S}_{it(\tau=1)}, j) = \frac{\exp(\bar{u}_{ikt}^B / \sigma_u^B)}{\sum_{l \in \mathcal{C}_{it(\tau=1)}} \exp(\bar{u}_{ilt}^B / \sigma_u^B))} \tag{14}$$

Similarly, conditional on M's wage w_{it}^M (observed for workers), the candidate/cohabiting social father's

[40] All census tract variables are defined as of 1999 using M's location. Unfortunately, local wages are not available at the census tract level and we use household income as a proxy.

quality Q_t, other state variables $\boldsymbol{S}_{it(\tau=2)} = (B_t, S_t, E_t,\ w^B_{it}, h^B_{it}, p_{CS,it})$, and biological family type j, let $\bar{u}^M_{ikt}(w^M_{it}, Q_t, \boldsymbol{S}_{it(\tau=2)}, j)$ denote M's alternative-specific value to alternative $k \in \mathcal{C}_{it(\tau=2)}$ that is exclusive of her preference shock, where $\mathcal{C}_{it(\tau=2)}$ is the indexed representation of M's choice set. M's choice probability is

$$P^M_{ikt}(w^M_{it}, Q_t, \boldsymbol{S}_{it(\tau=2)}, j) = \frac{\exp(\bar{u}^M_{ikt}/\sigma^M_u)}{\sum_{l \in \mathcal{C}_{it(\tau=2)}} \exp(\bar{u}^M_{ilt}/\sigma^M_u))} \tag{15}$$

When $S_t = 0$, Q_t is unobserved and M's choice probability is integrated out according to the matching technology $\Phi(\tilde{\alpha}_Q + \beta_Q \mu^M_{wj})$, which is a function of M's skill endowment μ^M_{wj} in biological family type j. We denote:

$$\tilde{P}^M_{ikt}(w^M_{it}, \boldsymbol{S}_{it(\tau=2)}, j) = \begin{cases} \Phi(\cdot)P^M_{ikt}(w^M_{it}, Q_t = 1, \boldsymbol{S}_{it(\tau=2)}, j) + (1 - \Phi(\cdot))P^M_{ikt}(w^M_{it}, Q_t = 0, \boldsymbol{S}_{it(\tau=2)}, j) & \text{if} \quad S_t = 0 \\ P^M_{ikt}(w^M_{it}, Q_t, \boldsymbol{S}_{it(\tau=2)}, j) & \text{if} \quad S_t = 1 \end{cases} \tag{16}$$

The joint choice probability of B and M is:

$$P^B_{ikt}(w^B_{it}, \boldsymbol{S}_{it(\tau=1)}, j)\tilde{P}^M_{ikt}(w^M_{it}, \boldsymbol{S}_{it(\tau=2)}, j) \tag{17}$$

where $\boldsymbol{S}_{it(\tau=2)}$ is a function of $\boldsymbol{S}_{it(\tau=1)}$, as defined earlier. Denote B and M's observed choice by k^B_{it} and k^M_{it}, respectively, which include information about their work status (h^B_{it} and h^M_{it}). The likelihood contribution is:

$$L_{it}(\boldsymbol{S}_{it(\tau=1)}, j) = \begin{cases} P^B_{i(k^B_{it})t}(w^B_{it}, \boldsymbol{S}_{it(\tau=1)}, j)\tilde{P}^M_{i(k^M_{it})t}(w^M_{it}, \boldsymbol{S}_{it(\tau=2)}, j) f^B(w^B_{it}|j) f^M(w^M_{it}|j) & \text{if} \quad h^B_{it} = 1, h^M_{it} = 1 \\ P^B_{i(k^B_{it})t}(w^B_{it}, \boldsymbol{S}_{it(\tau=1)}, j) f^B(w^B_{it}|j) \int \tilde{P}^M_{i(k^M_{it})t}(w^M, \boldsymbol{S}_{it(\tau=2)}, j) f^M(w^M|j) dw^M & \text{if} \quad h^B_{it} = 1, h^M_{it} = 0 \\ \int P^B_{i(k^B_{it})t}(w^B, \boldsymbol{S}_{it(\tau=1)}, j)\tilde{P}^M_{i(k^M_{it})t}(w^M_{it}, \boldsymbol{S}_{it(\tau=2)}, j) f^M(w^M_{it}|j) f^B(w^B|j) dw^B & \text{if} \quad h^B_{it} = 0, h^M_{it} = 1 \\ \int P^B_{i(k^B_{it})t}(w^B, \boldsymbol{S}_{it(\tau=1)}, j) \int \tilde{P}^M_{i(k^M_{it})t}(w^M, \boldsymbol{S}_{it(\tau=2)}, j) f^M(w^M|j) dw^M f^B(w^B|j) dw^B & \text{if} \quad h^B_{it} = 0, h^M_{it} = 0 \end{cases} \tag{18}$$

where $f^B(.)$ and $f^M(.)$ are B and M's probability density of the wage equation, respectively.[41]

Recall in Section 3.5 that the initial relationship status B_{i0} is endogenous (see equation (13)). In a

[41] For nonworkers, the integral is computed using a Gauss-Hermite quadrature.

panel data with N biological families, the log likelihood function is

$$LL = \sum_{i=1}^{N} \ln \sum_{j=1}^{J} \pi_j Pr(B_{i0} = 1|j) \prod_{t=0}^{\mathcal{T}} L_{it}(\boldsymbol{S}_{it(\tau=1)}, j). \tag{19}$$

where π_j is the probability that the biological family belongs to type j and $Pr(B_{i0} = 1|j)$ captures the initial relationship status.

Due to our definition of relationship status and choice, the relationship choice b_t, s_t in the last sample period is unobserved. We compute the likelihood function by integrating out the unobserved choices; for example, if we observe M's choice is to work part-time, invest and receive welfare support (denoted by event C), we add the probabilities: $Pr(C, b = 0, s = 0) + Pr(C, b = 1, s = 0) + Pr(C, b = 0, s = 1)$, and use it in the likelihood. We apply the same approach to cases where B's work status is missing (about 7% of observations). Among observations with $S_t = 1$ (M-S relationship), 74 observations have the social father's quality missing; we integrate out the social father's quality in these cases.

3.7 Estimation Results from the Choice Model

A total of 80 parameters are estimated in the choice model. The estimates and standard errors of the parameters are reported in Table A3. The first two columns of the first half of the table report the estimates from log wage equations. Relative to fathers with no college exposure, fathers with at least some college exposure have wages that are 19 log points higher.[42] For mothers, this wage gap is 27 log points. These differences are moderate compared to the distribution of parental unobserved skill endowments. The wage gap between lowest-skill-type fathers and highest-skill-type fathers is 109 log points (=0.17+0.92), while this gap is 78 log points among mothers (=0.05+0.73).[43] Hence unobserved skill endowments play an important role in explaining wages.

Our estimates reveal interesting combinations of skill endowments by the biological family's type. In type-1, type-2 and type-3 families, the father has a higher skill endowment than the mother. The majority of biological families belong to type 4 where the father has a lower skill endowment than the mother. In type-5 families, the skill endowments are similar between the father and the mother.

[42] In our sample, only 2 percent of fathers and mothers are college graduates. Less than one-fourth of fathers and mothers have at least some college exposure.

[43] The intercept estimates reflect the skill endowments of type-1 individuals. The type-specific intercepts reflect the wage differences between other types of individuals and type-1 individuals. For example, type-2 fathers have wages that are 17 log points (estimate=0.17) higher than type-1 fathers.

We find that the match quality (both in terms of μ_{bj} and β_{B0j}) increases by the father's level of skill endowment, i.e., the biological family has a higher tendency to be separated when the father's skill endowment is low.

Turning to relationship choices, we find that, unsurprisingly, the parameters imply substantial state dependence in relationships. Although education does not appear to explain relationship choice (despite father's education having some statistical significance), parents' early-life exposure to family relationships are strong determinants of relationship choice – if the father/mother lived with both biological parents when he/she was age 15, there is a much stronger tendency to choose M-B relationship. The pre-sample history of acquaintance between the mother and the father also predicts the initial M-B relationship status at child birth.

The technology of drawing social fathers, on the other hand, yield qualitatively different results from that of the relationship choice parameters. High-education mothers, as well as mothers with high skill endowment, have a much higher probability to draw high-quality social fathers. However, mothers with high skill endowment are less likely to choose an M-S relationship. We find that mothers do not appear to favor high-quality as opposed to low-quality social fathers. The availability of high-quality candidates in the local area substantially increases the probability of drawing high-quality social fathers.

The second half of Table A3 reports choice parameters related to work, quality time, child support and welfare choices. Parents with some college exposure have a higher perceived value for work and paying child support, and a lower perceived value for receiving welfare. While high-education mothers have a higher perceived value for quality time, this relationship is absent among high-education fathers. Interestingly, if the father lived with both biological parents when he was age 15, he has a higher perceived value for quality time; yet this relationship is absent among mothers.

The remaining parameters in the table are interaction terms that aim to capture potential differences in the choice combinations of each parent. The results appear to suggest different implicit constraints faced by the father and the mother. If the father works, his perceived value for quality time increases; on the contrary, if the mother works, her perceived value for quality time reduces. Fathers in an M-B relationship have a higher perceived value for work, while mothers in an M-B or M-S relationship have a lower perceived value for work. Fathers in an M-B relationship have a much higher perceived value for quality time than father who are separated from the mother, in particular when the mother is in an M-S relationship. Mother's perceived value for quality time does not appear to vary by relationship status.

To assess the model's goodness-of-fit, we simulate the model for 30 paths per biological family and compare the simulated outcomes with actual ones in Table 5 (choices and relationships) and Figure 2 (wages). The model fits the data well in all key dimensions.

4 Empirical Specification and Estimation of Child's Ability Production Function

4.1 Accounting for the Endogeneity of Inputs

Our objective is to obtain unbiased estimates of the effect of mother and father inputs on the child's ability, as measured by his/her ability test scores and behavioral scores at age T. The main source of bias stems from parental inputs being endogenous; they are correlated with unobserved heterogeneity of the parents, which may be correlated with unobservable traits of the child that determine observed scores directly. To illustrate the source of bias, consider the following stylized model:

$$\tilde{A}_{iT} = \gamma_0 + \boldsymbol{x}_{Ai}^{'}\boldsymbol{\gamma}_1 + \boldsymbol{M}_{iT}^{'}\boldsymbol{\gamma}_2 + \rho_T \nu_i + \epsilon_{AiT}, \tag{20}$$

where $\tilde{A}_{iT}$ denotes child i's observed test score at child's age T, $\boldsymbol{x}_{Ai}$ is a vector of child-specific covariates, $\boldsymbol{M}_{iT}$ denotes a vector containing the history of parental inputs up to child's age T, ν_i represents the child's unobserved endowment effect with a loading ρ_T that is specific to the child's age, and ϵ_{AiT} is a pure transitory shock or measurement error. Suppose the child endowment ν_i is positively correlated with the mother's and/or father's unobserved ability as measured by skill endowment in the labor market (μ_{wi}^M and/or μ_{wi}^B). Then, parental inputs ($\boldsymbol{M}_{iT}$) will potentially be correlated with ν_i, resulting in an omitted variable bias. For example, mothers with high unobserved ability tend to have high child endowment, and they also tend to work more because of higher wages and are in different types of relationships.[44]

Following Chan and Liu (2018), we address the potential source of endogeneity bias by a control

[44]Note that, even with test score data collected from two periods, the first-difference or fixed effects model will not eliminate contribution of the latent child's skill endowment because the loading ρ_T is age-specific (also see Todd and Wolpin (2003)).

function approach, where the estimated choice model is used to predict parental unobserved characteristics. In particular, parental skill endowments (and hence the child endowment), conditional on their observed behavior will enter into the child ability production function as control functions, based on the premise that parental skill endowments are correlated with the child's unobserved endowment. For instance, we can control for the child endowment effect using a prediction of the mother's and father's unobserved ability as covariates:

$$E(\rho_T \nu_i | \boldsymbol{M}_{iT}, \boldsymbol{x}_{Ai}, \boldsymbol{Z}_i) = \delta^M_{wT} \underbrace{E(\mu^M_{wi} | \boldsymbol{M}_{iT}, \boldsymbol{x}_{Ai}, \boldsymbol{Z}_i)}_{\equiv K^M_{wiT}} + \delta^B_{wT} \underbrace{E(\mu^B_{wi} | \boldsymbol{M}_{iT}, \boldsymbol{x}_{Ai}, \boldsymbol{Z}_i)}_{\equiv K^B_{wiT}} \tag{21}$$

where the parameters δ^M_{wT} and δ^B_{wT} capture the association between the mother's and father's unobserved ability and the child endowment effect. The control functions are implicitly functions of the set of exclusion restrictions ($\boldsymbol{Z}_i$) discussed in Section 3.6, including state-specific policy rules, local area characteristics and parents' early-life exposure to family relationships. Importantly, the exclusion restrictions are not included in $\boldsymbol{x}_{Ai}$ and are independent from the transitory shocks ϵ_{AiT} and hence they do not affect the child's ability directly. It is this source of variation that allows us to identify the control function parameter in the ability production function.

The control functions can be evaluated from the estimated choice model directly. For instance, the mother's control function can be evaluated by

$$K^M_{wiT} = \sum_{j=1}^{5} \mu^M_{wj} Pr(type = j | \boldsymbol{M}_{iT}, \boldsymbol{x}_{Ai}, \boldsymbol{Z}_i) = \sum_{j=1}^{5} \mu^M_{wj} \frac{Pr(\boldsymbol{M}_{iT} | type = j, \boldsymbol{x}_{Ai}, \boldsymbol{Z}_i) Pr(type = j)}{\sum_{l=1}^{5} Pr(\boldsymbol{M}_{iT} | type = l, \boldsymbol{x}_{Ai}, \boldsymbol{Z}_i) Pr(type = l)}. \tag{22}$$

In the choice model, there are five discrete unobserved types of biological families (i.e., $j = 1, ..., 5$), so the conditional mean is obtained by a weighted average. The weighted average can be computed, as the type-specific ability μ^M_{wj}, conditional probability $Pr(\boldsymbol{M}_{iT} | type = j, \boldsymbol{x}_{Ai}, \boldsymbol{Z}_i)$ given type j, and type probability $Pr(type = j)$ can all be retrieved directly from the choice model. K^M_{wiT} can differ substantially across mothers with different observed behavior because of selection into work, time spent with children and relationship choices. In the empirical model, the conditional type probabilities are conditional on all information in the panel data that are used for choice model estimation. This includes the parents' choices, wages (observed if employed), relationship status and covariates. This yields the "best" summary of the mother's unobserved type given the data available. The conditional probabilities are computed by applying Bayes rule on the likelihood contribution and type probabilities.

As discussed in Chan and Liu (2018), a main shortcoming of this "hybrid" approach is that we lose a unifying theory that explains children's development process. For example, the "full structural" approach involves jointly estimating the production function with the parents' decision problem.[45] For instance, if the parents' well-being is a function of the child's cognitive ability, then, any changes to child's ability will make parents have different incentives to invest in their children. Of course, the full process can only be formally specified under an explicit set of assumptions, for example, the mother knows the production function. Under the "hybrid" approach, this process is kept implicit in the choice model. In particular, we can no longer estimate the "deep" utility parameter of interest (i.e., the importance of the child's ability to the parents' utility) and cannot study how parents react to unexpected changes in child's ability. The estimation of the production function is mainly treated as an econometric issue.

4.2 Empirical Specification

Our empirical specification of the child ability production function builds on the expository model outlined in Section 3.2. Iterating equations (1) and (2) successively by age, we link the measurement of child's ability at age 5 with cumulative parental inputs made between age 1 and 5. As our simplest specification, we first consider the following empirical regression:

$$\tilde{A}_i = \bar{A}_i + \gamma_h \sum_{a=1}^{5} h_{ia}^M + \gamma_m^M \sum_{a=1}^{5} m_{ia}^M + \gamma_m^B \sum_{a=1}^{5} m_{ia}^B + \gamma_s \sum_{a=1}^{5} s_{ia} + \gamma_y \ln \sum_{a=1}^{5} y_{ia} + \epsilon_{Ai}, \tag{23}$$

where the observed ability measure at age 5 ($\tilde{A}_i$) is determined by total years (between child's age 1 and 5) of maternal employment (h_{ia}^M), high quality time spent with the child (separately by each parent; m_{ia}^M and m_{ia}^B) and cohabitation with a social father (s_{ia}), together with the logarithm of cumulative household income (y_{ia}) and time-invariant characteristics of the child $\bar{A}_i$. Because time investments only capture a limited set of parental-child activities, the inclusion of maternal employment captures the effects of maternal childcare broadly. By holding maternal employment constant, the coefficient on

[45] In Section 3.3, we explain the limitations that prevent us from pursuing the "full structural" approach.

household income can be interpreted as an income effect.[46] Household income includes labor income from mother and cohabiting father, child support and TANF benefits. It can be regarded as a proxy for investment expenditure related to children, under the assumption that households spend a fixed fraction of income on child-related expenditure. $\bar{A}_i$ contains observable characteristics including the mother and father's education, as well as the conditional means of the mother's and father's unobserved ability K^M_{wi} and K^B_{wi}:

$$\bar{A}_i = \gamma_0 + \boldsymbol{x}'_{Ai}\boldsymbol{\gamma}_1 + \delta^M_w K^M_{wi} + \delta^B_w K^B_{wi}. \tag{24}$$

The last two terms represent the control functions discussed above, which proxy the child's unobserved endowment.

The regression in equation (23) imposes constant marginal returns to parental inputs. The effects of parental inputs on ability can differ by the mother and/or father's education level and skill endowment. Time spent with social father may also differential returns depending on the education level of the social father. To allow for heterogeneity in the return to parental inputs, we have the following preferred empirical specification:

$$\begin{aligned}\tilde{A}_i = \bar{A}_i &+ \gamma_h \sum_{a=1}^{5} h^M_{ia} + \gamma^e_h (\sum_{a=1}^{5} h^M_{ia}) \times e^M_i + \gamma^M_m \sum_{a=1}^{5} m^M_{ia} + \gamma^{M,e}_m (\sum_{a=1}^{5} m^M_{ia}) \times e^M_i \\ &+ \gamma^B_m \sum_{a=1}^{5} m^B_{ia} + \gamma^{B,e}_m (\sum_{a=1}^{5} m^B_{ia}) \times e^B_i + \gamma_s \sum_{a=1}^{5} s_{ia} + \gamma^e_s \sum_{a=1}^{5} s_{ia} \times Q_{sa} + \gamma_y \ln \sum_{a=1}^{5} y_{ia} + \epsilon_{Ai}\end{aligned} \tag{25}$$

Under this specification, the return to father time with child may differ by father characteristics, e^B_i; returns to maternal employment and mother time with child may differ by mother characteristics, e^M_i. As father and mother characteristics, we consider their education levels as well as their unobserved ability as predicted by the control functions from the choice model. For instance, as e^B_i, we include two indicator variables, one for whether the father has a college education and the other for whether father's predicted ability (K^B_{wi}) is above the median in the population. Finally, we also allow cohabitation with a college-educated social father to have additional return on child's ability. This is captured by the additional parameter γ^e_s (Q_{sa} takes the value of 1 if the social father has at least some college

[46] We also tried to include total years of father's cohabitation with the mother as an additional input in the production function (equation (23)). The effect is small and insignificantly different from zero, implying that, holding parental time inputs constant, cohabitation status alone has little effects on child's test score.

education).[47]

We also consider additional specifications. For example, equation (23) assumes that return to father time spent with children is invariant to relationship status. One might be interested in examining whether father time with child is more effective when the father is cohabiting with the mother. This hypothesis can be examined empirically by separating years of high-level quality time spent with child by relationship status (i.e. by distinguishing input made when father cohabits with the mother and input after separation). Equation (24) can also include the conditional mean of unobserved heterogeneity in preference for relationship quality. These results are further discussed in Section 4.3, along with a value-added specification of the production function where we relate age-5 test scores to age-5 parental inputs and lagged test scores measured at age 3.[48]

For each child, there are three different scores: PPVT test scores, externalizing behavior, and internalizing behavior. Estimation is carried out separately for each type of ability, using the same set of covariates. Estimation is carried out in two stages. First, the conditional means of unobserved heterogeneity corresponding to each child's parents are computed using the choice model. Then, the model is estimated using OLS, using actual inputs as well as the conditional means as covariates. Our baseline sample consists all children with non-missing scores.

4.3 Estimation Results

4.3.1 Cognitive Ability

Table 6 reports estimates from PPVT test score regressions among children of age 5.[49] Columns 1 and 2 are based on the empirical specification in equation (23). Column 1 does not have any control functions. After adding control functions (column 2), the coefficient on family income is reduced by half and becomes insignificant. This suggests that family income is strongly correlated with mother and father unobserved ability. If mother and father unobserved abilities are not controlled for, the

[47] Social father education is not available in the wave 1 survey, hence $Q_{s1} = 0$ for all social fathers in wave 1 (only 5.7% of mothers were cohabiting with a social father in wave 1).

[48] Even without our control functions, the value-added specification may produce consistent estimates so long as the lagged test score provides a sufficient statistic for all historical inputs and unobserved child-specific endowment. Our control function approach allows us to test this assumption explicitly, by including the control functions in an value-added regression specification and testing the joint significance of the predicted mother and father skill endowments. See Section 4.3.4 for more discussions.

[49] As discussed earlier, the estimation sample includes children who have nonmissing PPVT test scores at age 3 and age 5. There are 1181 children included in the cognitive ability regression.

estimated return from family income will be biased up. The coefficient on the father skill endowment control function (K^B_{wi}) is positive and significant. However, conditional on father skill endowment, mother skill endowment is not strongly correlated with child's ability test score.[50] Both parents' education are positively correlated with child's ability score, with mother's education more positively associated with child's score than father's (the coefficient is 0.048, versus 0.038 among fathers).

Column (2) shows that an additional year of maternal employment will increase the score by 1.9 percent (0.11 sd), and an additional year of mother's quality time with child increases the score by 0.9 percent (0.05 sd). Consistent with Chan and Liu (2018), the positive effect of maternal employment may be interpreted as maternal child care being less effective than formal and informal care among this group of relatively low-education mothers. Relative to mothers, time inputs from fathers exhibit very small returns; both the return from father's quality time with child and the presence of a social father does not seem to affect child's ability by age 5. Therefore, taken on face value, our results imply that father inputs, on average, play little role in affecting child's ability production by age 5.

However, the overall return from father's input masks significant heterogeneity in the returns across different types of fathers. To differentiate the impacts of different types of fathers, we turn to columns 3 and 4, which are based on our preferred empirical specification in equation (25). Column (3) shows that the return to father time investment differs significantly by father ability–the interaction between years of father quality time and dummy for high-ability father is positive and significant. Indeed, for high-ability fathers, their return to time investment is positive and significant (-0.008+0.019=0.011; p-val=0.058). Interestingly, the return to father time investment does not seem to vary by father's education level, highlighting the importance of identifying "latent" ability of the father. We also find some evidence that an additional year spent with a college-educated social father has a differential positive effect on child's ability, although the difference is not statistically significant.

In column (4), we further include additional interactions of mother time inputs with mother's ability types and education. None of the additional interactions are statistically significant, indicating that there is far less heterogeneity in the return to mother's time investment. Overall, our estimates suggest that return to mother's time investment on child's cognitive ability is relatively homogenous

[50] Figure 3 plots the distribution of predicted skill endowment conditional on observed behavior (K_{wi}) for mothers and fathers. For both parents, there is sizable variation in predicted skill endowment. Father tend to have a larger spread in predicted skill endowment than mothers (father sd is 0.21, versus mother sd of 0.17).

and positive, but there is a wide spread of the return to father's time investment with the marginal returns increasing with father's ability. Our results highlight the role of both fathers and mothers in determining children's cognitive development.[51]

4.3.2 Noncognitive Ability

The results from externalizing and internalizing score regressions further reveal additional asymmetry in the returns to maternal and paternal time inputs. The full results are reported in Tables 7 and 8.[52] Similar to cognitive ability, we find that maternal quality time with child tends to reduce internalizing behavior. Externalizing behavior, however, is not significantly affected by additional maternal quality time spent with child. We find that father time investment improves noncognitive ability of the child on average, but only limited to reducing externalizing behavior (column (2) in Table 7). Similar to the production of cognitive skills, high-ability fathers can produce differentially large effects from their time investment on reducing externalizing behavior–the interaction term between father time inputs and father ability is negative and significant (column (3) in Table 7). Taken together, our estimates suggest that one additional year of time investment by a high-ability father can reduce the child's externalizing behavioral score by 0.03 (=-0.025-0.005; 0.12 sd), whereas one additional year with a low-ability father has little impact on child's externalizing behavior.

Overall, our finding suggests that, for externalizing behavior, fathers play a relatively more important role relative to mothers. Holding other inputs constant, we find that even social fathers can potentially have a positive influence in affecting child's externalizing behavior. For instance, estimates from column (3) of Table 7 shows that an additional year living spent with a college-educated social father can reduce the externalizing behavior score by 0.04 (0.018-0.058=-0.04). Mothers, on the other hand, play a more important role in the development of cognitive skills and internalizing behavior. These asymmetric returns, across different types of test and by different members in the family, illustrate the empirical importance of analyzing returns from parental inputs made by different members

[51] One might be interested in comparing the marginal return to father time investment with the marginal return to mother's time investment. For mothers, one additional year of high quality time with child corresponds to an average of 2.1 days per week extra time with child (given the definition of mother's high quality time in Section 2). Given the definition of father's high quality time, one additional year of father's high quality time with child corresponds to an average of 3.7 days per week extra time with child. This means that we need to scale up the estimated mother return by a factor of 3.7/2.1=1.76 in order to make the marginal returns comparable between mothers and fathers. This implies that the returns to mother's time investment are unanimously larger than even the return from high-ability fathers.

[52] Relative to cognitive ability, mother and father skill endowments are only weakly associated with externalizing and internalizing scores.

of the family.

4.3.3 Interpreting the Results

The differential impacts of parental time investment on cognitive scores are broadly consistent with findings from the literature emphasizing the importance of language environment in early childhood in shaping abilities later in life. Cognitive ability scores measure skills related to reading and language ability, and the environment at early ages is shown to be an important factor in shaping these skills. Studies have found that children from disadvantaged environments are exposed to a substantially less rich vocabulary than children from more advantaged families (Hart and Risley (1995), Fernald, Marchman, and Weisleder (2013)). In our data, we find that mothers spend disproportionately more time with children in reading and telling stories than fathers (see Appendix Figure A1), indicating that mother in the family has the first and foremost role of creating a language environment which is beneficial to child's cognitive ability in reading.

The developmental psychology literature has suggested important differences between mothers and fathers in the style of attachment relationships they provide. In Paquette's father-child activation relationship theory (Paquette, 2004), fathers are important because of the unique and biologically determined ways they interact with their children. In particular, Paquette (2004) theorizes that father 'excite, surprise, and momentarily destabilize children'; they encourage risk taking while simultaneously protecting their young from danger. Children's experiences of arousing play enable them to display courage in the face of unfamiliar events and foster children's 'openness to the world'. By contrast, the mother-child attachment relationship focuses on caretaking, calm and comfort rather than arouse, which are more closely related to emotional state and internalizing behavior (Grossmann, Grossmann, Fremmer-Bombik, Kindler, Scheuerer-Englisch, Zimmermann, and Peter, 2002). These parental differences in the types of child attachment relationship may provide an explanation to our findings–that mothers are more important affecting children's internalizing behavior, whereas fathers are more important influencing their externalizing behavior.

The similarity in mother's role in the development of cognitive skills and internalizing behavior suggests that the formation of cognitive and non-cognitive skills may be interlinked. Bornstein, Hahn, and Suwalsky (2013) find that early language competency be developmentally linked to internalizing behavioral adjustment but not to externalizing behavior. Their evidence supports a positive association between language skills in early childhood and internalizing behavior in later childhood; from as early as 4 years of age, language skills can already be linked to internalizing behavior problems. These findings are offer an alternative explanation–that maternal time inputs are important to the language environment in the family, which in turn promotes the development of child's cognitive ability and reduces internalizing behavior problems.

4.3.4 Robustness Checks and Additional Specifications

We estimate additional specifications of the production function based on the discussion in Section 4.2. We begin by relaxing the restriction that the control functions are only related to father and mother ability types enter into the control functions. Column (1) of Table 9 reports the estimates when we include an additional control function: a M-B match quality control function. This additional control function is a prediction of the M-B unobserved heterogeneity in the choice model, similar to equation (22). The inclusion of M-B match quality control function makes the coefficient on the control function for father skill endowment not significant, because father skill endowment is positively correlated with initial M-B match quality. The coefficients on parental inputs are robust to the inclusion of the additional control function, suggesting that mother and father skill endowments already capture most unobserved heterogeneity which may bias the estimated returns to parental inputs.

Column (2) of Table 9 reports the estimates where we disaggregate cumulative father time input into two covariates, one documenting years of quality time made by a father cohabiting with the mother (and the child) and one recording years of father quality time when the father does not cohabit with the mother. While we do not find any evidence for differential returns for cognitive and internalizing behavior, we find some evidence that father input is more effective in reducing externalizing scores and hence improving noncognitive ability when the father cohabits with the mother and the child.

Our empirical specifications so far are built on the premise that child development is a cumulative process depending on the history of parental inputs and on innate ability. Our estimates depend on our ability to control for unobserved heterogeneity of the parents that are correlated with parental inputs and child's innate ability, and we have demonstrated that our results are robust to the inclusion of additional control functions. Table 10 reports results from a value-added specification, where we relate age-5 ability scores to contemporaneous (age-5) parental inputs and age-3 ability scores. The value-added approach may help alleviate the concern of endogeneity of inputs, under the assumption that a lagged test score provides a sufficient statistic for all historical inputs and unobserved child-specific endowment (Todd and Wolpin, 2003; Cunha, Heckman, and Schennach, 2010; Fiorini and Keane, 2014). Our control function approach allows us to test this assumption explicitly, by including the control functions in an value-added regression specification and testing the joint significance of the predicted mother and father skill endowments. We find that none of our coefficients on predicted mother/father skill endowment are significantly different from zero (they are not jointly different from zero either), lending support to the assumption that lagged test scores already absorb unobserved child-specific endowment. The value-added specification allows us to examine the return to age-5 (contemporaneous) parental input. We find that (1) maternal employment at age 5 improves cognitive ability whereas maternal time inputs do not; (2) father input improves noncognitive ability but does not affect cognitive ability on average; (3) there is a strong ability gradient in the return to father time input as high-ability father improves cognitive ability of the child significantly. All these findings are consistent with the findings from our preferred cumulative specification of production function.

5 Counterfactual Scenarios: Effects of Separation and Union Shocks on Child's Ability

In Section 2, we documented sizable PPVT test score differences by relationship status (final row of Figure 1), yet such differences may represent selection into relationship status (by unobserved father-mother characteristics) rather than causal relationships. In this section, we use the estimated child's ability production function and the choice model to analyze how shocks to family relationships affect child's ability, separating causal mechanisms from selection.

We begin by simulating the choice model under the "baseline scenario" in which the model is estimated and shown to have a good fit to the data. From the simulated data, we can predict the average child's ability scores at age 5, using the parameters as estimated in equation (25). We contrast the average child's ability scores predicted under the baseline with the child's ability scores predicted under three counterfactual scenarios. In the first counterfactual scenario, "M-B to Single", all mothers in a M-B relationship at $t = 0$ are externally assigned to become single at $t = 1$. Since relationship status at $t = 1$ is determined by the mother at $t = 0$, this is equivalent to a choice-specific preference shock to mothers that exogenously dissolves all the initial M-B relationships (e.g., a large negative preference shock to cohabiting with the father). We also consider two other counterfactual scenarios. In "Single to M-B", all single mothers at $t = 0$ are externally assigned to cohabit with fathers at $t = 1$ (an M-B union shock). In "Single to M-S", all single mothers at $t = 0$ are externally assigned to cohabit with a social father (regardless of the quality drawn) and form M-S families at $t = 1$ (an M-S union shock). Under each counterfactual scenario, we simulate the choice model, track cumulative inputs of mother, father and social father up to age 5 that enter the production function and compare how the average predicted child outcomes change relative to the baseline.

The differences in the average predicted child's ability between counterfactual scenarios and the baseline are presented in Figure 4. Because family relationship status at $t = 1$ is externally assigned in the counterfactuals, these differences represent causal impacts of family relationships at $t = 1$, abstracting from endogenous selection. Panel A shows the results on cognitive scores. We find that a separation shock (M-B to Single) at $t = 1$ leads to a small overall reduction (0.005sd) in child's cognitive ability scores. Decomposing the overall impact into contributions from mother, father and social father, we find that the negative impact is driven by the father. Following separation, the average cumulative time input by a high-ability father decreases from 1.67 to 1.19, which, according to our production function estimates, will have negative consequence on the cognitive ability scores of the child. Although mother's time spent with child and maternal employment are shown to have positive impacts, these choices do not change much when single mothers are separated from the fathers and consequently they do not sufficiently compensate for the negative impact caused by changes in father's inputs.

Not every family will be affected by the family status assignment in the counterfactual scenarios. For instance, only 35% of the population are affected by the "M-B to Single" assignment, meaning 35% of the population will have a different relationship status at $t = 1$ in the counterfactual (single) relative to the baseline (not single). Therefore, the reported changes in Figure 4 should be interpreted as the average effect of the separation shock in the population, equivalent to the average treatment effect if each counterfactual is regarded as a treatment. If instead one is interested in the average treatment effect on the treated, we need to scale the reported difference by the proportion of families whose relationships are affected by the treatment. In the "M-B to Single" case, this means that the average treatment effect on the treated is 0.005/0.35=0.014sd, which is still only a fraction of the observed test score gap between children in single families at age 1 and those in M-B families at age 1 (=0.12sd). This indicates that the majority of observed cognitive score differences by relationship status are due to selection.

Relative to the separation shock, we find that the M-B union shock (Single to M-B) leads to the most overall reduction in child's cognitive scores (-0.009sd) and the M-S union shock (Single to M-S) leads to improved cognitive scores (+0.017sd).[53] The improved child's cognitive outcome from cohabiting with a social father is due to the positive effect of living with a college-educated social father. On the contrary, cohabiting with the father at age 1 does not improve child's cognitive outcomes on average. The reason is that single mothers who are affected by the external assignment of cohabiting with the father at $t = 1$ are negatively selected in terms of father's ability. Indeed, among mothers who are affected by the treatment, the fraction of high-ability fathers is only 38.5%, much lower than the population average (at 50%). Although father's time spent with child increases following cohabitation (from 1.47 to 1.98), a disproportionate increase comes from increasing time inputs by low-ability fathers, which do not improve children's cognitive outcomes (see column (3) in Table 6). Moreover, the treatment crowds out the prospect of mothers cohabiting with potentially high-quality social fathers. This result highlights the importance of considering heterogeneity in the returns to parental inputs in child's ability production function. It also shows that family policies that encourage family formation should also pay attention to the quality of the fathers which mothers are matched to. If more mothers are matched with low-ability men, this may even have negative consequence on children's cognitive outcomes.

Panels B and C of Figure 4 report the results on externalizing and internalizing behavior, respectively. We find that the separation shock which makes M-B families to become single at age 1 worsens child's noncognitive outcomes by increasing externalizing and internalizing behavior (+0.027sd and +0.012sd, respectively). For externalizing behavior, this means that the average treatment effect on the treated is 0.027/0.35=0.077sd, which is about the same size as the observed gap between children in single families at age 1 and those in M-B families at age 1. This indicates that a sizable proportion of the observed gap is due to causal effects. Assigning single mothers to cohabit with fathers at age 1 improves child's noncognitive outcomes, more so for externalizing behavior (-0.025sd). Consistent with

[53] The shares in the population who are affected by "Single to M-B" and "Single to M-S" are 44% and 45%, respectively.

our findings in Section 4.3.2, these results highlight the importance of father involvement in promoting noncognitive skill development. In Section 4.3.2, we also find that cohabiting with a college-educated social father can improve child's noncognitive outcomes. By assigning single mothers to cohabit with a social father (Single to M-S), the increase of social father time with the child alone leads to a large reduction in externalizing and internalizing behavior. Meanwhile, the presence of social fathers crowds out time inputs by fathers, leading to an increase in the externalizing and internalizing behavior. The overall effect thus depends on the relative magnitude of the two effects, namely, the reduced involvement of the father and the increase in the presence of social fathers.

6 Conclusion

We developed and estimated a tractable economic model to study the causal impact of family structure on children's cognitive and non-cognitive outcomes among the disadvantaged population in the U.S. An innovative feature of our choice model is that we distinguished the selection process between biological and social(step) parental relationships. In our framework, parents and their children may differ systematically in their unobserved characteristics across different types of relationships, and social fathers are matched endogenously with the mother via a heterogeneous matching technology and selection process. To identify the heterogeneity of biological families, we used panel data following both biological parents inside and outside the relationship, combining with a set of exclusion restrictions including parents' early-life exposure to family relationships and state-specific policy rules. To identify the matching technology between the mother and the social father, we drew from census-tract characteristics as additional exclusion restrictions.

We estimated the causal impact of parental and family inputs on child skill formation via a control function approach. We find that father's time inputs between age 1 and 5 on average do not affect the cognitive skills of children at age 5. Yet there is significant heterogeneity in the returns to paternal time investment by their skill-endowment: high-ability fathers carry positive and significant returns whereas low-ability fathers can even generate negative returns. The differential returns by father skill endowment cannot be explained by differences in father's education level, highlighting the importance of using a choice model to identify the distribution of latent ability of fathers in the disadvantaged population. Paternal time also reduces externalizing (aggressive and rule-breaking) behavior, more so by high-ability fathers. Similar to high-ability fathers, the presence of college-educated social fathers in families also improves cognitive outcome and reduces externalizing behavior.

Our results suggest that family policies that incentivize (or disincentivize) mother and biological father cohabitation should pay attention to the *quality* of the fathers and potential social fathers in families, because children benefit the most in terms of both cognitive and noncognitive development by living with a high-quality father or social father. For instance, we showed in the paper that a shock which promotes family formation between single mothers and relatively low-ability biological fathers can lead to an overall reduction in child's cognitive scores at age 5. By promoting mothers to cohabit with low-ability men, the increased time investment from these fathers may even have negative consequence on children's cognitive outcomes. Moreover, it also crowds out the prospect of mothers finding potentially high-quality social fathers, who have positive impacts on child development.

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Table 2: Choices and Relationship Status by Child's Age

	Relationship Status (%)			Mother Choice (M, %)					Father Choice (B, %)		
Wave	Single	M-B	M-S	FT	PT	NW	Invest	TANF	Work	Invest	CS
0	52.3	47.7	0.0						76.1		
1	49.1	45.3	5.7	40.0	15.1	44.9	50.2	31.5	71.5	54.9	19.7
3	48.6	40.1	11.3	43.5	14.2	42.2	51.9	27.7	71.5	50.2	27.7
5	48.6	33.0	18.5	46.0	15.0	39.1	45.0	22.0	73.3	45.0	31.8
Total	49.6	41.5	8.9	43.2	14.8	42.1	49.1	27.1	73.1	50.0	26.8

Notes : M-B stands for mother cohabiting with (biological) father. M-S stands for mother cohabiting with a social/step father. *FT*, *PT*, and *NW* refers to mother full-time work, part-time work and not working, respectively. *Invest* is quality time spent with child (low=0, high=1). *TANF* is whether mother receives welfare (no welfare=0, welfare=1). *CS* is whether father pays child support (defined only for father not cohabiting with the mother).

Table 3: Dynamics of Relationship Status: Transition Rates

		Wave 0 to 1			Wave 1 to 3			Wave 3 to 5		
		To: (%)			To: (%)			To: (%)		
		Single	M-B	M-S	Single	M-B	M-S	Single	M-B	M-S
From:	Single	68.7	22.8	8.5	71.3	14.9	13.8	71.5	9.1	19.4
	M-B	27.5	69.9	2.6	24.4	71.9	3.8	24.6	70.8	4.7
	M-S	-	-	-	45.7	4.7	49.6	35.2	1.2	63.6
	Total	49.1	45.3	5.7	48.6	40.1	11.3	48.6	33.0	18.5

Notes : The first three rows report the conditional probabilities of family relationship status at age t (column headings) given the relationship status at age s ($s < t$; row headings). The final row reports the unconditional probabilities of family relationship status at age t.

Table 4: List of Covariates and Exclusion Variables

	Father (B)				Mother (M)					SF Draw	Initial
	Work	Invest	CS	Wage	Work	Invest	Live w/ B	Live w/ SF	Wage	Pr(college)	Relation
Father college	x	x	x	x			x				x
Mother college					x	x	x	x	x	x	x
Child support policies			**x**								
Years M knows B							**x**				**x**
M lived with parents @age 15						**x**	**x**	**x**			**x**
B lived with parents @age 15		**x**					**x**				**x**
Census tract variables:											
% bachelor degree										**x**	
Median HH income				**x**					**x**		
local unempl. rate	**x**				**x**						
M-B type intercepts				x			x		x		x
M's latent ability (linear)								x		x	

Note: Bolded ***x*** indicates an exclusion variable. SF: Social father.

Table 5: Goodness of Fit of the Choice Model

Wave		Relationship Status (%)			Mother Choice (%)					Father Choice (%)		
		Single	M-B	M-S	FT	PT	NW	Invest	TANF	Work	Invest	CS
0	Data	52.3	47.7	0.0						76.1		
	Predicted	*52.2*	*47.8*	*0.0*						*70.1*		
1	Data	49.1	45.3	5.7	40.0	15.1	44.9	50.2	31.5	71.5	54.9	19.7
	Predicted	*49.5*	*41.9*	*8.6*	*43.8*	*14.8*	*41.5*	*49.1*	*27.1*	*74.3*	*52.0*	*26.4*
3	Data	48.6	40.1	11.3	43.5	14.2	42.2	51.9	27.7	71.5	50.2	27.7
	Predicted	*48.7*	*37.9*	*13.4*	*43.5*	*14.7*	*41.8*	*48.9*	*27.3*	*73.7*	*48.8*	*26.6*
5	Data	48.6	33.0	18.5	46.0	15.0	39.1	45.0	22.0	73.3	45.0	31.8
	Predicted	*49.2*	*34.9*	*16.0*	*43.8*	*14.6*	*41.6*	*49.1*	*27.2*	*73.3*	*46.6*	*26.2*

Notes : Numbers in italics are predicted values from the choice model. See notes under Table 2 for definitions of abbreviations.

Table 6: Estimates of Skill Production Function: Cognitive Ability

Dependent variable: Ln(PPVT test score at age 5)	(1)	(2)	(3)	(4)
Years of mother quality time	0.009**	0.010**	0.009**	0.014**
	(0.004)	(0.004)	(0.004)	(0.006)
Years of maternal employment	0.019***	0.019***	0.020***	0.020***
	(0.005)	(0.005)	(0.005)	(0.005)
Years of father quality time	0.002	0.000	-0.008	-0.009
	(0.004)	(0.004)	(0.006)	(0.006)
Years of M-S relationship	-0.001	-0.000	-0.004	-0.004
	(0.007)	(0.007)	(0.008)	(0.008)
Ln(cumulative family disposable income)	0.009*	0.004	0.003	0.003
	(0.005)	(0.005)	(0.005)	(0.005)
Heterogeneity terms:				
Years of father quality time×high-ability father			0.019***	0.021***
			(0.006)	(0.007)
Years of father quality time×father college			-0.007	-0.008
			(0.009)	(0.009)
Years of M-S with a college social father			0.022	0.022
			(0.020)	(0.020)
Additional heterogeneity terms from mother:				
Years of mother quality time×high-ability mother				-0.007
				(0.007)
Years of mother quality time×mother college				-0.006
				(0.010)
Control function:				
Father skill endowment		0.066**	0.024	0.020
		(0.026)	(0.030)	(0.030)
Mother skill endowment		0.007	0.001	0.018
		(0.034)	(0.034)	(0.037)
Covariates:				
Mother college	0.050***	0.048***	0.047***	0.056***
	(0.012)	(0.012)	(0.012)	(0.019)
Father college	0.036***	0.038***	0.049**	0.051***
	(0.012)	(0.012)	(0.019)	(0.020)
R-squared	0.084	0.091	0.099	0.100

Notes : See Section 4.2 for details of the empirical specifications. $N = 1181$. * $p < 0.10$, ** $p < 0.05$, ***$p < 0.01$.

Table 7: Estimates of Skill Production Function: Externalizing Behavior

Dependent variable: Externalizing Behavior	(1)	(2)	(3)	(4)
Years of mother quality time	-0.010	-0.011	-0.010	-0.008
	(0.007)	(0.007)	(0.007)	(0.010)
Years of maternal employment	-0.013	-0.014	-0.014	-0.014
	(0.009)	(0.009)	(0.009)	(0.009)
Years of father quality time	-0.016**	-0.015**	-0.005	-0.004
	(0.007)	(0.007)	(0.009)	(0.009)
Years of M-S relationship	0.010	0.009	0.018	0.018
	(0.012)	(0.012)	(0.013)	(0.013)
Ln(cumulative family disposable income)	0.000	0.005	0.007	0.006
	(0.008)	(0.009)	(0.009)	(0.009)
Heterogeneity terms:				
Years of father quality time×high-ability father			-0.025**	-0.025**
			(0.010)	(0.011)
Years of father quality time×father college			0.011	0.011
			(0.015)	(0.015)
Years of M-S with a college social father			-0.058*	-0.057*
			(0.032)	(0.032)
Additional heterogeneity terms from mother:				
Years of mother quality time×high-ability mother				0.001
				(0.011)
Years of mother quality time×mother college				-0.008
				(0.016)
Control function:				
Father skill endowment		-0.054	-0.003	-0.003
		(0.042)	(0.049)	(0.049)
Mother skill endowment		-0.019	-0.001	-0.003
		(0.055)	(0.056)	(0.061)
Covariates:				
Mother college	-0.043**	-0.041**	-0.039*	-0.027
	(0.020)	(0.020)	(0.020)	(0.031)
Father college	-0.015	-0.017	-0.034	-0.034
	(0.020)	(0.020)	(0.032)	(0.032)
R-squared	0.024	0.026	0.034	0.035

Notes : See Section 4.2 for details of the empirical specifications. $N = 1181$. * $p < 0.10$, ** $p < 0.05$, ***$p < 0.01$.

Table 8: Estimates of Skill Production Function: Internalizing Behavior

Dependent variable: Internalizing Behavior	(1)	(2)	(3)	(4)
Years of mother quality time	-0.016***	-0.016***	-0.016***	-0.014*
	(0.005)	(0.005)	(0.005)	(0.007)
Years of maternal employment	-0.012*	-0.010	-0.010	-0.010
	(0.007)	(0.007)	(0.007)	(0.007)
Years of father quality time	-0.005	-0.004	-0.002	-0.002
	(0.005)	(0.005)	(0.007)	(0.007)
Years of M-S relationship	0.003	0.003	0.008	0.008
	(0.009)	(0.009)	(0.009)	(0.009)
Ln(cumulative family disposable income)	-0.002	0.001	0.002	0.002
	(0.006)	(0.007)	(0.007)	(0.007)
Heterogeneity terms:				
Years of father quality time×high-ability father			-0.009	-0.008
			(0.008)	(0.008)
Years of father quality time×father college			0.009	0.009
			(0.011)	(0.012)
Years of M-S with a college social father			-0.033	-0.033
			(0.024)	(0.024)
Additional heterogeneity terms from mother:				
Years of mother quality time×high-ability mother				-0.002
				(0.008)
Years of mother quality time×mother college				-0.004
				(0.012)
Control function:				
Father skill endowment		0.000	0.016	0.015
		(0.032)	(0.037)	(0.037)
Mother skill endowment		-0.066	-0.056	-0.051
		(0.041)	(0.042)	(0.046)
Covariates:				
Mother college	-0.028*	-0.030**	-0.028*	-0.023
	(0.015)	(0.015)	(0.015)	(0.023)
Father college	-0.008	-0.008	-0.022	-0.022
	(0.015)	(0.015)	(0.024)	(0.024)
R-squared	0.024	0.027	0.030	0.030

Notes : See Section 4.2 for details of the empirical specifications. $N = 1181$. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 9: Estimates of Skill Production Function: Robustness Check

Dependent variables	A. Additional Control Function			B. Father Input by Relationship		
	Ln PPVT	External	Internal	Ln PPVT	External	Internal
Years of mother quality time	0.010**	-0.010	-0.016***	0.010**	-0.010	-0.016***
	(0.004)	(0.007)	(0.005)	(0.004)	(0.007)	(0.005)
Years of maternal employment	0.019***	-0.013	-0.010	0.019***	-0.017*	-0.009
	(0.005)	(0.009)	(0.007)	(0.006)	(0.009)	(0.007)
Years of father quality time	0.000	-0.014*	-0.005			
	(0.004)	(0.007)	(0.005)			
Years of M-S relationship	0.000	0.009	0.004	-0.001	0.007	0.004
	(0.007)	(0.012)	(0.009)	(0.007)	(0.012)	(0.009)
Ln(cumulative family disposable	0.003	0.004	0.001	0.005	0.011	-0.001
income)	(0.005)	(0.009)	(0.007)	(0.006)	(0.009)	(0.007)
Separate father quality time outside/inside relationship:						
Years of father quality time				-0.002	-0.024***	-0.001
inside a relationship				(0.005)	(0.008)	(0.006)
Years of father quality time				0.004	0.000	-0.009
outside a relationship				(0.006)	(0.010)	(0.008)
Control function:						
Father skill endowment	0.113	0.061	-0.038	0.066**	-0.051	-0.001
	(0.083)	(0.134)	(0.101)	(0.026)	(0.042)	(0.032)
Mother skill endowment	0.006	-0.021	-0.066	0.007	-0.022	-0.065
	(0.034)	(0.055)	(0.041)	(0.034)	(0.055)	(0.041)
Additional Control function:						
M-B match quality	-0.005	-0.012	0.004			
	(0.008)	(0.013)	(0.010)			
Covariates:						
Mother college	0.050***	-0.040**	-0.029**	0.048***	-0.041**	-0.029**
	(0.012)	(0.020)	(0.015)	(0.012)	(0.020)	(0.015)
Father college	0.038***	-0.018	-0.007	0.038***	-0.016	-0.008
	(0.013)	(0.020)	(0.015)	(0.013)	(0.020)	(0.015)
R-squared	0.091	0.027	0.027	0.091	0.030	0.027

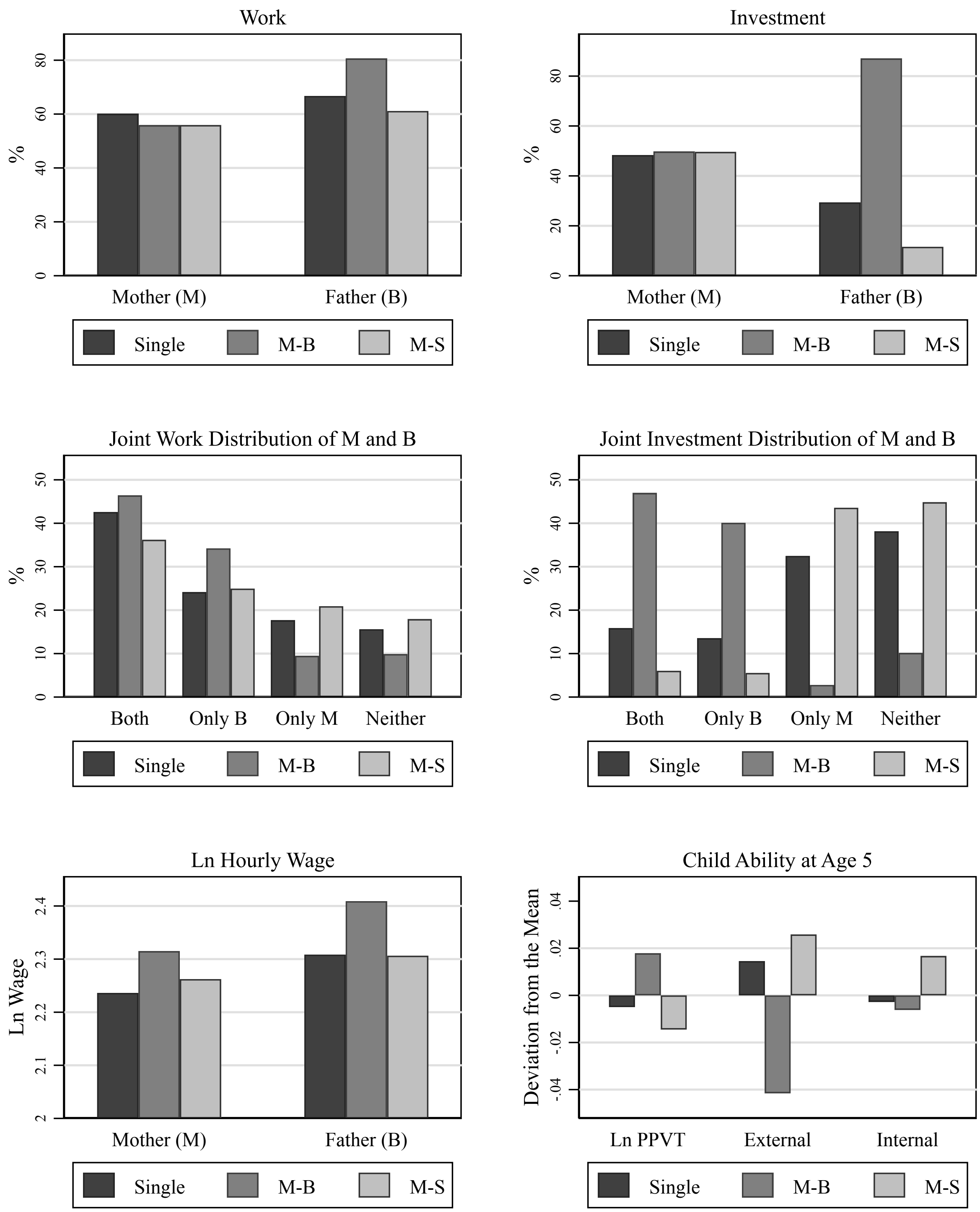
Notes : See Section 4.2 for details of the empirical specifications. Columns "Ln PPVT" is the log standardized PPVT test scores at age 5, "External" is the externalizing behavioral scores at age 5, and "Internal" is the internalizing behavioral scores at age 5. $N = 1181$. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 10: Estimates of Skill Production Function: Autoregressive Specification

Dependent variables	Ln PPVT	External	Internal
Ln(PPVT score at age 3)	0.294***		
	(0.022)		
External Behavior at age 3		0.396***	
		(0.018)	
Internal Behavior at age 3			0.367***
			(0.022)
Additional variables at age 5:			
Mother quality time at age 5	0.003	-0.001	-0.003
	(0.009)	(0.013)	(0.010)
Mother work at age 5	0.033***	-0.005	-0.009
	(0.011)	(0.017)	(0.013)
Father quality time at age 5	-0.012	-0.010	-0.027*
	(0.013)	(0.020)	(0.016)
Father quality time at age 5×high-ability father	0.059***	0.007	0.019
	(0.015)	(0.023)	(0.018)
Father quality time at age 5×father college	-0.025	0.027	0.015
	(0.021)	(0.032)	(0.025)
M-S relationship at age 5	-0.003	0.033*	0.019
	(0.013)	(0.019)	(0.015)
M-S relationship with a college social father at age 5	0.034	-0.032	-0.016
	(0.027)	(0.040)	(0.032)
Ln(family disposable income at age 5)	-0.002	0.001	0.002
	(0.003)	(0.004)	(0.003)
Control function:			
Father skill endowment	0.004	-0.044	-0.003
	(0.027)	(0.040)	(0.032)
Mother skill endowment	0.009	0.007	-0.036
	(0.030)	(0.045)	(0.036)
Covariates:			
Mother college	0.040***	-0.023	-0.005
	(0.011)	(0.016)	(0.013)
Father college	0.047***	-0.012	-0.010
	(0.016)	(0.023)	(0.019)
R-squared	0.222	0.309	0.212

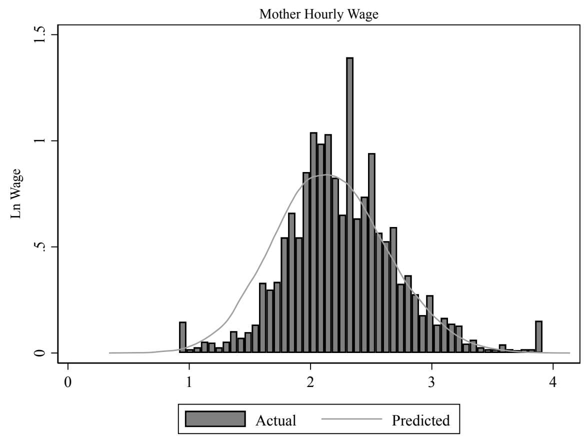
Notes : See Section 4.2 for details of the empirical specifications. Columns "Ln PPVT" is the log standardized PPVT test scores at age 5, "External" is the externalizing behavioral scores at age 5, and "Internal" is the internalizing behavioral scores at age 5. $N = 1181$. * $p < 0.10$, ** $p < 0.05$, ***$p < 0.01$.

Figure 1: Mother and Father Choices by Relationship Status

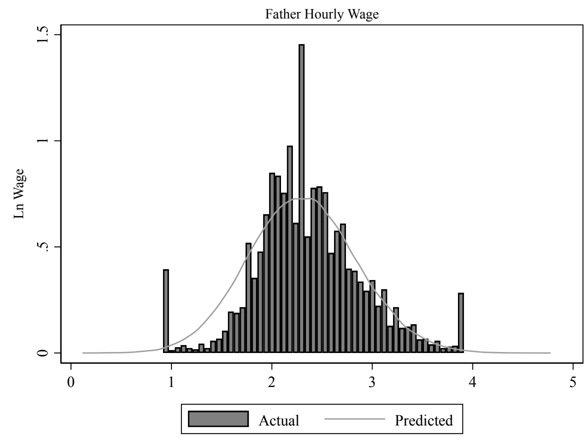


Notes : Mean of Ln PPVT scores = 4.51; Mean of externalizing behavior scores = 0.46; Mean of internalizing behavior scores = 0.26. In the first five plots, we use data from surveys when the focal child was 1, 3, and 5 years of age. In the last plot on child ability, we only use information from the age-5 survey (hence family relationship status is measured at age 5).

Figure 2: Goodness of Fit: the Log Wage Distribution



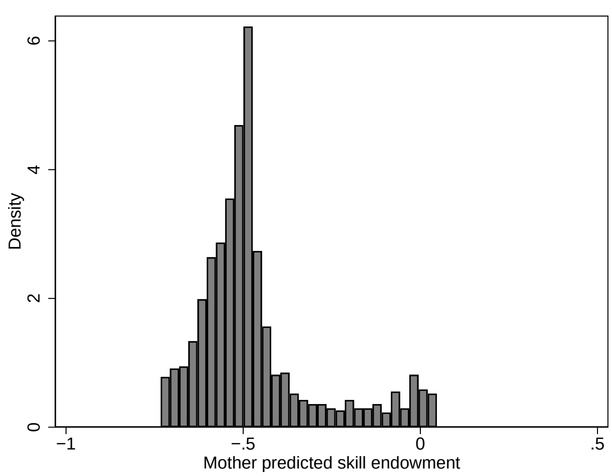
(a) Mother Hourly Wage

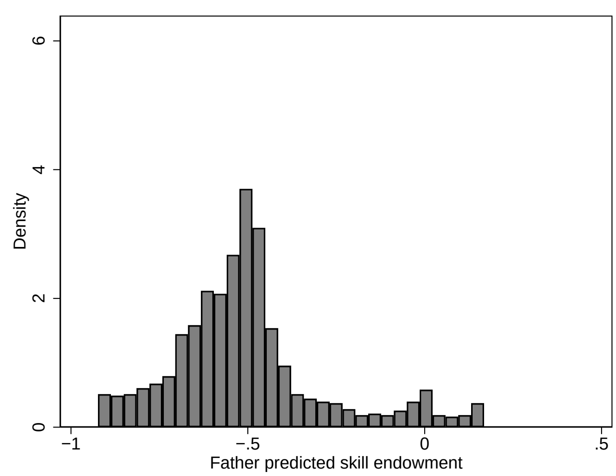


(b) Father Hourly Wage

Notes : Comparison between the actual distribution of log hourly wage in the sample (separated by mother and father) and the distribution of the same log wage as predicted by our model.

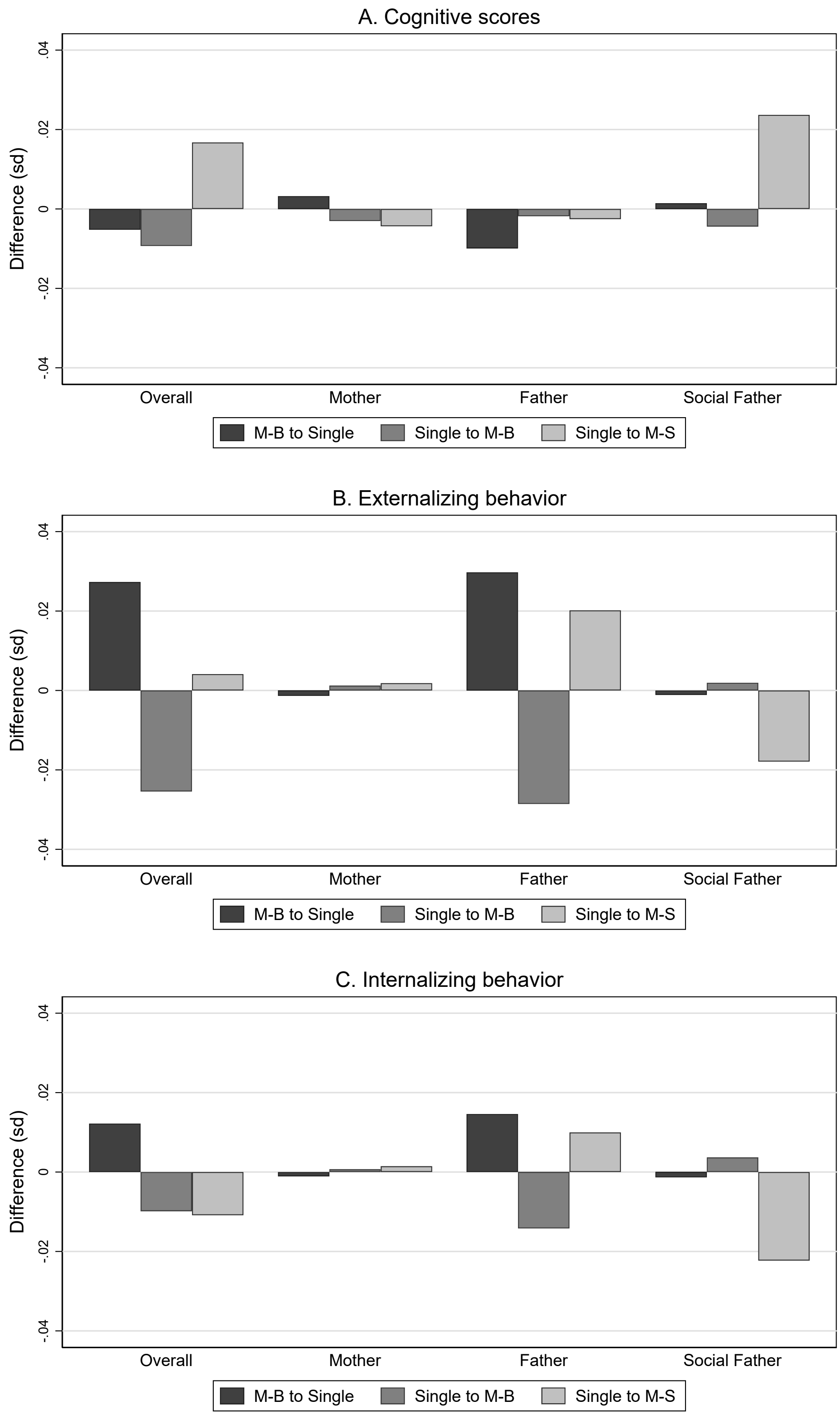
Figure 3: Distribution of Father and Mother Predicted Skill Endowment





Notes : This figure shows the predicted means of father and mother unobserved skill endowments conditional on their observed behavior.

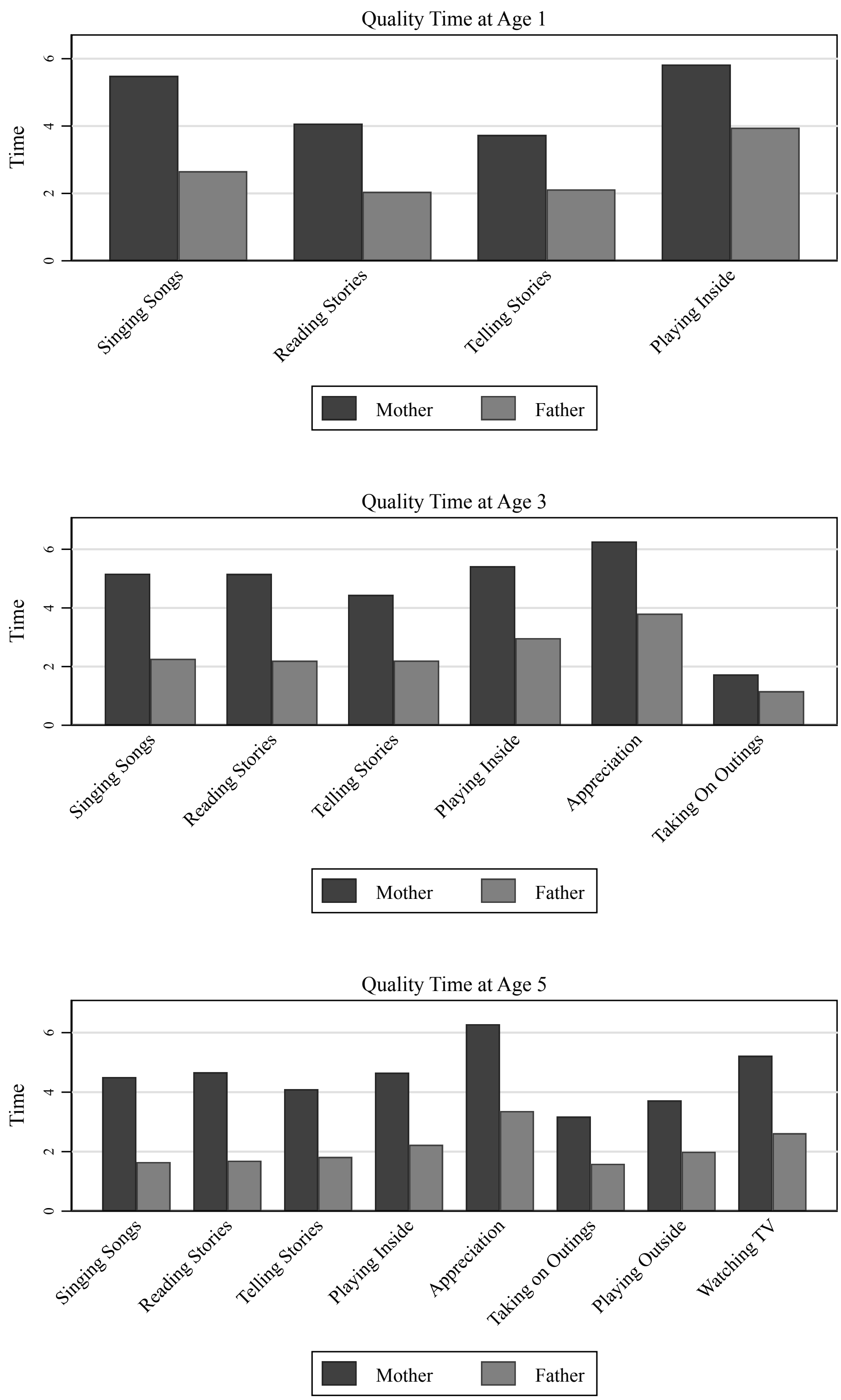
Figure 4: Changing Family Relationships and Children's Outcomes



Notes : "Overall" is the average predicted change in children's outcome at age 5 between the baseline and the following counterfactuals: (1) all M-B families at $t = 0$ become single at $t = 1$ (M-B to Single), (2) all single mothers at $t = 0$ are assigned to cohabit with the father at $t = 1$ (Single to M-B), and (3) all single mothers at $t = 0$ are assigned to cohabit with a social father at $t = 1$ (Single to M-S). "Mother", "Father" and "Social Father" refer to the changes in child's outcome that are due to changes in mother, father and social father inputs, respectively.

Appendix Tables and Figures

Figure A1: Parental Quality Time with Child, by Activity Types



Notes : This figure reports the average engagement intensity with the focal child (by age) across different activities that form the index of quality-time spent with child used in the paper. The engagement intensity is measured by the numbers of days which the parent does each of the activities in a typical week.

Table A1: List of Variables Related to Internalizing and Externalizing Behaviours, Year 3 Survey

	variable	Question
Internalizing Behavior	m3	he/she clings to adults or is too dependent
	m16	(he/she) feelings are easily hurt
	m19	he/she gets too upset when separated from parents
	m22	he/she looks unhappy w out good reason
	m25	(He/She) is nervous, high strung, or tense
	m26	he/she is overtired
	m32	he/she is self-conscious or easily embarrassed
	m37	he/she is too shy or timid
	m42	(he/she) is too fearful or anxious
	m46	he/she is unhappy, sad, depressed
	m48	he/she wants a lot of attention
	m1	he/she acts too young for age
	m2	he/she avoids looking others in the eye
	m9	he/she doesn't answer when people talk to (him/her)
	m10	he/she doesn't get along with other children
	m11	he/she doesn't know how to have fun, or he/she acts like little adult
	m13	he/she doesn't seem to feel guilty after misbehaving
	m29	he/she refuses to play games
	m31	he/she seems unresponsive to affection
	m35	he/she shows little affection toward people
	m36	he/she shows little interest in things around (him/her)
	m39	he/she is stubborn, sullen, or irritable
	m44	he/she is uncooperative
	m45	he/she is under active, slow moving, or lacks energy
	m50	he/she is withdrawn -does not get involved with others
Externalizing Behavior	m5	he/she is defiant
	m6	(his/her) demands must be met immediately
	m7	he/she is disobedient
	m14	he/she is easily frustrated
	m17	he/she is easily jealous
	m18	he/she gets in many fights
	m21	he/she hits others
	m23	he/she has angry moods
	m28	punishment doesn't change (hihe/sher) behavior
	m30	he/she screams a lot
	m33	he/she is selfish or won't share
	m40	(he/she) has sudden changes in mood or feelings
	m41	(he/she) has temper tantrums or hot temper
	m47	he/she is unusually loud
	m49	he/she is whiny
	m2a	(he/she) can't concentrate, can't pay attention for long
	m3b	(he/she) is cruel to animals
	m6a	he/she destroys his/her own things
	m6b	(he/she) destroys things belonging to his family or oth children
	m18a	(he/she) gets into everything
	m21a	(he/she) hurts animals or people without meaning to
	m28a	(he/she) quickly shifts from one activity to another

Table A2: List of Variables Related to Internalizing and Externalizing Behaviours, Year 5 Survey

	variable	Question
Internalizing Behavior	l5	(he/she) complains of loneliness
	l17	(he/she) fears that (he/she) might think or do something bad
	l18	(he/she) feels (he/she) has to be perfect
	l19	(he/she) feels or complains that no one loves (him/her)
	l20	(he/she) feels others are out to get (him/her)
	l29	(he/she) feels too guilty
	l43	(he/she) is self-conscious or easily embarrassed
	l53	(he/she) is suspicious
	l65	(he/she) worries
	l25	(he/she) would rather be alone than with others
	l38	(he/she) refuses to talk
	l42	(he/she) is secretive, keeps things to self
	l46	(he/she) is shy or timid
	l47	(he/she) stares blankly
	l52	(he/she) sulks a lot
	l61	(he/she) is underactive, slow moving, or lacks energy
	m4b4b4	True/not true: child cries a lot?
	m4b4b18	True/not true: child feels worthless or inferior?
	m4b4b9	True/not true: child is nervous, high strung, or tense?
	m4b4b14	True/not true: child is too fearful or anxious?
	m4b4b15	True/not true: child is unhappy, sad, depressed?
	m4b4b17	True/not true: child is withdrawn child doesn't get involved with others?
Externalizing Behavior	l1	(he/she) argues a lot
	l2	(he/she) brags or boasts
	l7	(he/she) is cruel, bullies and shows meanness to others
	l9	(he/she) destroys (his/her) own things
	l10	(he/she) destroys things belonging to family or others
	l12	(he/she) is disobedient at home
	l13	(he/she) is disobedient at school or in childcare
	l16	(he/she) is easily jealous
	l21	(he/she) gets in many fights
	l33	(he/she) physically attacks people
	l40	(he/she) screams a lot
	l45	(he/she) shows off or clowns around
	l56	(he/she) talks too much
	l57	(he/she) teases a lot
	l59	(he/she) threatens people
	l62	(he/she) is unusually loud
	l23	(he/she) hangs around with others who get in trouble
	l26	(he/she) lies or cheats
	l36	(he/she) prefers being with older kids
	l39	(he/she) runs away from home
	l44	(he/she) sets fires
	l49	(he/she) steals at home
	l50	(he/she) steals outside the home
	l54	(he/she) swears or uses obscene language
	l64	(he/she) vandalizes
	m4b4b16	True/not true: child wants a lot of attention?
	m4b4b11	True/not true: child is stubborn, sullen or irritable?
	m4b4b12	True/not true: child has sudden changes in mood or feelings?
	m4b4b13	True/not true: child has temper tantrums or a hot temper?
	m4b4b7	True/not true: child doesn't seem to feel guilty after misbehaving?

TABLE A3: Choice Model Estimates

Covariate	Father's log wage	Mother's log wage	Choose M-B	Choose M-S	Draw good S	M-B at birth
Intercept	2.50 (0.02) ***	2.37 (0.02) ***	-12.36 (1.91) ***	-22.63 (2.76) ***	0.13 (0.37)	0.06 (0.14)
M-B status			27.04 (1.24) ***	-2.95 (1.40) **		
M-S status				22.51 (1.53) ***		
Single status & ever had M-B				2.42 (1.33) *		
Father some college	0.19 (0.02) ***		1.68 (0.92) *			0.17 (0.07) **
Mother some college		0.27 (0.02) ***	-1.14 (0.89)	-2.17 (1.45)	0.49 (0.06) ***	-0.06 (0.07)
Father w/ bio parents at age 15			2.23 (0.81) ***			0.14 (0.07) **
Mother w/ bio parents at age 15			2.71 (0.77) ***	0.84 (1.04)		0.24 (0.06) ***
Years M knows B at child birth			0.14 (0.11)			0.02 (0.01) **
Median household income[a,c]	0.008 (0.00) ***	0.005 (0.00) ***				
Local w/ bachelor degree[b,c]					1.09 (0.24) ***	
Social father has high quality				2.90 (4.92)		
Mother's skill endowment				-9.35 (4.23) **	1.30 (0.50) ***	
Type 2 intercept	0.17 (0.04) ***	-0.64 (0.05) ***	-2.05 (2.83)			-0.04 (0.23)
Type 3 intercept	-0.47 (0.02) ***	-0.49 (0.02) ***	-5.86 (1.81) ***			-0.30 (0.14) **
Type 4 intercept	-0.68 (0.04) ***	0.05 (0.04)	-10.40 (2.89) ***			-0.44 (0.22) *
Type 5 intercept	-0.92 (0.03) ***	-0.73 (0.03) ***	-10.40 (2.19) ***			-0.73 (0.16) ***
Stdev of wage shock	0.43 (0.00) ***	0.37 (0.00) ***				
<u>Type probabilities (MNL):</u>						
Type 2	-0.38 (0.28)					
Type 3	-0.53 (0.27) **					
Type 4	1.81 (0.19) ***					
Type 5	0.66 (0.25) ***					

(Continues)

TABLE A3 --- *Continued*

Covariate	Father Work	Mother work	Father quality time	Mother quality time	Child support	Welfare
Intercept	21.09 (2.81) ***	-17.16 (0.95) ***	-28.83 (3.04) ***	-0.15 (0.47)	-36.92 (3.73) ***	-9.89 (0.43) ***
Father's Education	16.98 (2.26) ***		0.87 (1.79)		5.02 (1.81) ***	
Mother's Education		6.74 (0.76) ***		2.93 (0.51) ***		-9.71 (0.80) ***
Local unemployment rate[b,c]	-94.17 (10.84) ***	-3.92 (3.20)				
Father w/ bio parents at age 15			4.75 (1.73) ***			
Mother w/ bio parents at age 15				0.31 (0.46)		
Child support enforcement (%)					8.22 (1.32) ***	

Other preference parameters:	Father	Mother
Full-time work		2.05 (0.63) ***
Work × Quality time	3.72 (1.89) **	-2.51 (0.54) ***
Work × M-B status	10.44 (2.29) ***	
Work × (M-B/M-S status)		-3.67 (0.56) ***
Quality time × M-B status	76.75 (7.02) ***	
Quality time × M-S status	-31.96 (4.06) ***	
Quality time × (M-B/M-S status)		0.46 (0.50)
Stdev of choice shock	27.67 (3.92) ***	11.10 (0.62) ***

Note: N=2240. Log-likelihood = -60261.25. A total of 80 parameters are estimated. Father refers to the biological father. M: mother. M-B: mother cohabiting with the father. M-S: mother cohabiting with a social father. Type probability estimates are expressed as multinomial logit (MNL) coefficients. Standard errors are in parentheses and are computed using the outer-product-of-gradient estimator, which is consistent for the inverse Fisher information. Significance level (t-test for testing if each parameter=0): *** 1%, ** 5%, *10%.

[a] In thousand dollars per annum.

[b] As a proportion, ranging from 0 to 1.

[c] Census-tract level characteristic.