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Maternal breastfeeding and children's cognitive development☆

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ABSTRACT

Do children with lower test scores benefit more from breastfeeding than those with higher scores? In this paper, I examine the distributional effects of maternal breastfeeding on the cognitive test scores of 11,544 children who were born in 2000 and 2001 in the United Kingdom using a semiparametric quantile regression model. I find evidence that maternal breastfeeding has larger positive impacts on children with lower test scores. Effects for children below the 20th percentile are about 2–2.5 times greater than those for children above the 80th percentile. I also find that these distributional effects are larger when the duration of breastfeeding is extended. One policy implication is that a public policy aims at promoting breastfeeding might narrow a disparity in children's cognition.

1. Introduction

Economic theories of human capital have emphasized the importance of parental investment in children (Becker, 1981; Cunha and Heckman, 2007). A large number of empirical studies show that human capital developments in early childhood (e.g., cognitive ability) play a significant role in human capital developments later in life, as measured by educational attainment, employment, wages, etc. (Heckman, 2006; Cunha and Heckman, 2007; Cunha et al., 2010; Almond and Currie, 2011a,b).

Maternal breastfeeding has been emphasized as an influential factor in early childhood development (e.g., Kramer et al., 2001, 2008) based on biological mechanisms through which maternal breastfeeding aids children's development. First, the composition of breast milk is superior to that of formula. Breast milk contains long-chain polyunsaturated fatty acids, such as docosahexaenoic acid (DHA) and arachidonic acid (AA), which form the major structures of neuronal membranes and play critical roles in nervous system functioning by positively stimulating development of the human brain (Fernstrom, 1999). Infants require sufficient amounts of these acids during the first few months after birth (Clandinin et al., 1981). Note that the compositional superiority of breast milk may be reduced because DHA and AA are now added to formula. However, Fitzsimons and Vera-Hernandez (2012) reported that DHA and AA were not included in formula in the UK (the context of this paper) until most of the infants who are considered in the empirical analysis were born. Deoni et al. (2013) provided MRI evidence that breastfed infants exhibit better development in specific brain areas associated with language and visual reception abilities compared to those who are fed formula or a mixture of breast milk and formula. Second, skin-to-skin contact between mother and child stimulates maternal hormonal responses such as the production of prolactin and oxytocin, which may indirectly improve cognitive development (Del Bono and Rabe, 2012).

In spite of this clear biological mechanism, empirical evidence for the effects of breastfeeding on children's cognitive development has been conflicting. A comprehensive review by the Agency for Healthcare Research and Quality (Ip et al., 2007) summarized 400 articles (out of 9000 abstracts) and found that breastfeeding has few or small effects on children's cognitive ability. Many studies are based on observational data, and it is difficult to infer causality due to many potential confounding variables, such as duration of breastfeeding, children's demographics and birth outcomes (such as birth weight and gestational age), parental health-related behavior, socioeconomic status (SES), intelligence, and family characteristics (Anderson et al., 1999).

Researchers use various empirical strategies to address the endogeneity issue. First, they estimate the probability of breastfeeding using detailed information regarding the characteristics of

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children, parents, and families. They then estimate the effects of breastfeeding on cognitive development by comparing children with similar propensities of maternal breastfeeding (Jiang et al., 2011; Belfield and Kelly, 2012; Borra et al., 2012; Rothstein, 2012; Cesur et al., 2017). For example, Jian, Foster and Gibson-Davis (2011) used the Panel Study of Income Dynamics in the U.S. and found that the positive associations between breastfeeding initiation and children's cognitive development measured by the Woodcock Johnson Psycho-Educational Battery Revised (WJ-R) and Wechsler Intelligence Scale for Children-Revised (WISC-R) were significantly reduced when observational characteristics were controlled for. The estimated associations are between one-tenth and one-fifth of a standard deviation, which is small in magnitude. Second, some researchers use sibling or family fixed effects to control for unobserved family characteristics (Der et al., 2006; Rees and Sabia, 2009; Colen and Ramey, 2014; Cesur et al., 2017). Recent research points out that maternal intelligence or IQ and home environment explain breastfeeding status better than other SES factors such as income or education, but few previous studies have accounted for these covariates (Der et al., 2006). Many studies using the propensity score approach or fixed effects analysis have found that a positive association became smaller or disappeared once a large number of confounding factors were controlled for. Researchers pointed out these results as evidence for the endogeneity issue in breastfeeding (Belfield and Kelly, 2012; Cesur et al., 2017). Third, economists use exogenous sources of variation in breastfeeding status as instrumental variables to study the causal relationship between breastfeeding and children's cognitive development (Del Bono and Rabe, 2012; Fitzsimons and Vera-Hernandez, 2012). For example, infant feeding support is provided by midwives and nurses in the U.K. Since staff working hours are reduced during the weekend, this support is reduced as well. Mothers are less exposed to support when they give birth on Friday or Saturday. Fitzsimons and Vera-Hernandez (2012) use this institutional fact to estimate the effects of breastfeeding on children's cognitive development among low-income mothers and their children. Finally, Kramer et al. (2001, 2008) studied the causal effects of the Promotion of Breastfeeding Intervention Trial (PROBIT), which randomly provided health care worker assistance for the initiation and maintenance of breastfeeding, on breastfeeding initiation and duration and consequences for children's health and cognitive abilities in Belarus.

Previous literature mainly focused on the average effects of breastfeeding on children's cognition. Many measures for cognition, such as test scores, are continuously distributed. These distributions could provide a deeper understanding of the effects of breastfeeding on children's cognition by evaluating the effects at different quantiles in addition to the average effects. For example, children at lower quantiles could benefit more from breastfeeding than average children or children at higher quantiles, even though the average effects of breastfeeding are small or insignificant based on the existing literature. However, there is little knowledge regarding the effects of breastfeeding on the distribution of cognition. To fill this gap, I investigated the effects of maternal breastfeeding on the distribution of children's cognitive ability in this study. More specifically, I estimated the effects of breastfeeding at different quantiles of cognitive test scores using a semi-parametric quantile regression model. To address the endogeneity of breastfeeding, I used the propensity score as the inverse probability (Rosenbaum and Rubin, 1983; Hirano et al., 2003). Based on rich information about children's characteristics, cognitive test scores, and maternal breastfeeding from the UK Millennium Cohort Survey, I compared cognitive test scores among children with similar propensities for maternal breastfeeding based on observed parental characteristics.

2. Method

2.1. Data

To investigate the effects of maternal breastfeeding on children's development, I used data from the Millennium Cohort Study (MCS), a longitudinal study of about 18,500 children who were born in 2000 and 2001 in the United Kingdom. Specifically, I used data from four surveys (at ages 9 months, 3 years, 5 years, and 7 years) and excluded data for multiple births and children who were not living with their biological mothers at the time of the first interview ($n = 293$). Since I used secondary observational data, ethics approval was not required.

I collected data on self-reported maternal breastfeeding status from the first MCS survey, which included a question about the duration of maternal breastfeeding. Mothers reported the age of babies when breastfeeding stopped, as measured in days, weeks, or months, which was used for calculating the duration of breastfeeding. It was not feasible to obtain data on exclusive breastfeeding from the MCS because survey questions related to infant feeding were not exhaustive. Since the recommended duration of breastfeeding in the UK was 4 months in 2000, I created a binary breastfeeding variable indicating whether children were breastfed for at least 4 months. To study the effects of breastfeeding with different duration cutoffs, I examined the effects of initiation of breastfeeding. Given current policy recommendations [e.g., from the World Health Organization (WHO)], I also examined the effects of extended breastfeeding (i.e., for at least 6 months).

To assess children's cognitive development, I used scores from six British Ability Scale (BAS) tests, which are used to measure the cognitive abilities of children aged 2.5–8 years old (Elliott et al., 1997). Since these tests are individually administered by trained interviewers, the scores provide a more accurate measure than parents' self-reported measures (Fernald et al., 2009). Using the age-adjusted scores from the MCS, I calculated average scores within and across ages and created a summary index. I did this to address a concern that one null hypothesis could be rejected simply because I tested it with multiple null hypotheses (Kling et al., 2007). This also yields a well-behaved continuous distribution of test scores (Fig. 1).

I also collected information on maternal demographics, maternal prenatal characteristics, and spouse and family characteristics as control variables for the propensity score approach: mother's age at birth, race, marital status, and education; planned

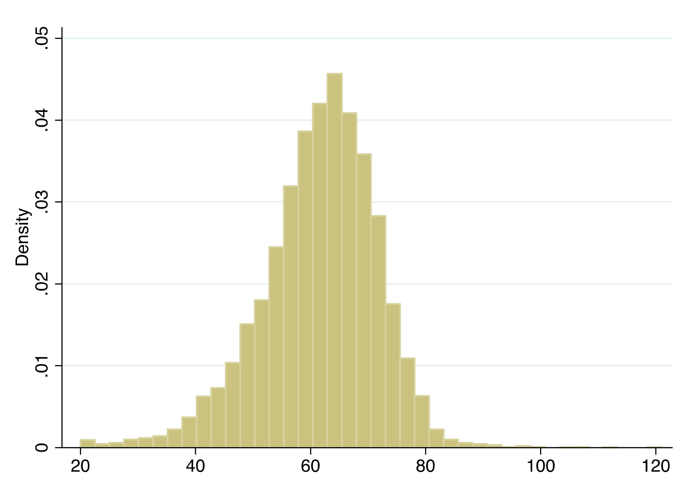

Fig. 1. Distribution of children's cognitive development. Data source: The MCS.