To Work or Not to Work? Child Development and Maternal Labor Supply[†]

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We estimate the effect of early child development on maternal labor force participation. Mothers of poorly developing children may remain at home to care for their children. Alternatively, mothers may enter the labor force to pay for additional educational and health resources. Which action dominates is the empirical question we answer in this paper. We control for the potential endogeneity of child development by using an instrumental variables approach, uniquely exploiting exogenous variation in child development associated with child handedness. We find that a one unit increase in poor child development decreases maternal labor force participation by approximately 10 percentage points. (JEL J13, J16, J22)

Understanding the socioeconomic factors affecting child development has become an increasingly important issue as the number of children diagnosed with development problems increases worldwide (see, for example, Stephan Collishaw et al. 2004; Eric Fombonne 1998; Barbara Maughan, Alessandra Iervolino, and Collishaw 2005; Janet Currie and Mark Stabile 2006). In this paper, we investigate one of the important potential effects of poor child development, namely, the effect that poor development has on maternal labor force participation. Mothers of poorly developing children may choose to remain at home to care for their children. Alternatively, mothers may decide to enter the labor force to pay for additional educational and health resources (see Elise Gould (2004) for a theoretical model). This paper aims to provide new insight into which of these potentially conflicting maternal labor supply responses empirically dominates.

While we are unaware of any other economic studies that directly estimate the impact of child development on maternal labor market decisions, there are a number of studies in a related literature that provide evidence on the effect of various

child health problems (see David S. Salkever 1982; Barbara L. Wolfe and Steven C. Hill 1995; Elizabeth T. Powers 2001; Hope Corman, Kelly Noonan, and Nancy E. Reichman 2005). The results from these studies indicate that poor child health generally has a negative effect on maternal employment and, to a lesser extent, hours worked. For example, Powers (2003) finds that child disability reduces females labor force participation by 6 percentage points and reduces desired work by 3.7 hours per week. However, a limitation of this literature is that most studies have not been able to control for the potential endogeneity of child health, given the practical difficulty in identifying exogenous variation to use for identification.[1]

We face a similar issue when estimating the impact of child development on maternal labor supply if there are unobservable characteristics relating to the mother and child that are correlated with both child development and maternal labor force participation and/or if maternal employment itself has a direct impact on child development. If maternal employment has a negative impact on child development, because of less time available in the home, for example, then children of working mothers will be less developed than children of nonworking mothers, creating a downward bias on the estimated impact. Conversely, if maternal employment has a positive impact on child development because of greater family income, then the estimated impact would be biased upward.

To control for the potential bias introduced by the endogeneity of poor child development, we exploit a natural experiment, namely, the allocation of handedness. Johnston et al. (2009) show that handedness is a strong predictor of early child development, and that handedness appears to be an exogenous source of variation in child development. Our data source is the Longitudinal Study of Australian Children (LSAC), in which detailed information was collected from parents and teachers on the development and welfare of children aged 4–5 in 2004. As a measure of development, we use the number of developmental areas (emotional, learning, language, gross motor, and fine motor) in which the child is assessed as "less competent" or "much less competent" than other children. We find evidence of a strong and robust causal impact of poor early child development on maternal labor force participation, with the results from a two-stage least squares (2SLS) model suggesting that a one unit increase in our measure of poor child development decreases maternal labor force participation by approximately 10 percentage points. The considerable difference we find between the magnitude of this estimated effect and the OLS effect is possibly caused by a strong negative impact of maternal participation on child development.

I. Data, Definitions, and Sample Characteristics

The data we use is drawn from the first wave of the LSAC collected in 2004.[2] The study tracks two cohorts of infants and children: children less than 12 months old in

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[1] Some exceptions, however, do exist. For example, Corman et al. (2005) attempt to control for the potential endogeneity of child health by using the number of adoption agencies per 10,000 women in the city in which the child was born and the presence of a Level III neonatal intensive care unit in the hospital where the baby was delivered.

[2] The LSAC Web site is www.aifs.gov.au/growingup/home.html.

2003–2004 who will be followed until they reach 6 to 7 years of age, and children aged 4–5 years in 2003–2004 who will be followed until they reach 10 or 11 years of age. In this paper, we use information on just under 5,000 children from the older cohort, children aged 4–5 (83 percent are 4 years of age). Data on one child from each household is collected using a clustered (by postcode) sample design, and it is intended that the samples be representative of all Australian children in each of the selected age cohorts.[3] Children in the remotest areas of Australia are less likely to be captured in the data, however.

The data we use are collected from parents and the child's preschool or kinder-garten teacher. The interviews with parents are conducted face-to-face by a trained interviewer in the child's home, and the interviewer also undertakes direct obser-vations and assessments of the child. The interview for the older cohort takes 2.5 hours, on average, so the interviewer is in a strong position to provide assessments of the child.

Information on the handedness of each child is given by the LSAC interviewer. In particular, the interviewer is asked to determine dominant handedness immediately after the child conducts lengthy tasks that involve the child copying shapes, writing words, and writing numbers. The interviewer is asked "Did the child use his/her (1) right hand, (2) left hand, (3) both hands, or (4) unsure?" We classify children as mixed-handed if the interviewer is sure the child is both-handed or if the interviewer is unsure whether the child is both-handed or right/left handed. In both instances, the child has demonstrated no dominant hand preference throughout the lengthy testing procedures.[4] Since we use an interviewer assessed measure of dominant handed-ness, we do not have to worry about parents who might misreport handedness of their child due to their own preferences for having a right-handed child.[5] Using this measure, approximately 10 percent of the children are assessed to be left-handed and approximately 5 percent of the children are assessed to be mixed-handed (see Table 1).[6] While it has been documented that the majority of children have already developed a clear hand preference at six months of age, a small minority of children will show no strong preference until later in life (see D. V. M. Bishop 1990), and, so, some mixed-handed children may still develop a preference for one hand over another as they become older.

The data from the teachers is collected via mail questionnaires. We use teacher evaluations of children's relative performance in five skill areas to construct our measure of child development. The use of teacher assessed measures of child development, rather than more subjective measures based on parental reports, is

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[3] More details of the sampling design can be found in Matthew Gray and Ann Sanson (2005).

[4] There is no statistical difference in our development measure of children who were classified as "both-handed" ($N = 64$) and children who were classified as "unsure" ($N = 106$): t-stat $= 0.46$, p-value $= 0.64$. This result provides support for our definition of mixed-handedness. In addition, we conducted all analysis recoding children classified as "unsure" to missing values. The results were not qualitatively different from those presented in Section III.

[5] For example, historically, there has been a tendency toward cultural censorship of left-handedness in certain Asian countries (e.g., Ling-fu Meng 2007). Though it is very unlikely that parents in contemporary Australia would force their children to use their right hand.

[6] While the incidence of left-handedness obviously varies across cultures and over time, 10 percent of the world population would be classified (or classify themselves) as left-handed, on average (Kevin Denny and Vincent O'Sullivan 2007).

TABLE 1—SAMPLE DESCRIPTIVE STATISTICS

	All		Mother nonparticipant		Mother participates	
	(1)		(2)		(3)	
Mother participates	0.614	(0.009)	0.000	—	1.000	—
Poor child development	0.837	(0.024)	1.032	(0.038)	0.715***	(0.030)
Left-handed	0.101	(0.005)	0.117	(0.009)	0.090**	(0.007)
Mixed-handed	0.054	(0.004)	0.061	(0.006)	0.050	(0.005)
Main control variables						
Male	0.509	(0.009)	0.526	(0.014)	0.497	(0.011)
Age 5	0.179	(0.007)	0.174	(0.011)	0.183	(0.009)
Birth weight (kg)	3.409	(0.010)	3.388	(0.017)	3.422	(0.013)
Intensive care birth	0.148	(0.006)	0.151	(0.010)	0.146	(0.008)
Premature birth	0.112	(0.006)	0.122	(0.009)	0.107	(0.007)
Multiple birth	0.028	(0.003)	0.027	(0.005)	0.029	(0.004)
Number of older siblings	0.900	(0.017)	0.990	(0.028)	0.843***	(0.022)
Number of younger siblings	0.548	(0.011)	0.699	(0.018)	0.453***	(0.014)
Preschool at school	0.467	(0.009)	0.492	(0.014)	0.451**	(0.011)
Preschool center	0.310	(0.008)	0.350	(0.013)	0.285***	(0.010)
Preschool at daycare	0.192	(0.007)	0.142	(0.011)	0.224***	(0.009)
Mother's age	34.63	(0.102)	33.84	(0.164)	35.13***	(0.130)
Mother's age squared	12.33	(0.067)	11.90	(0.107)	12.60***	(0.085)
Mother has degree	0.299	(0.008)	0.211	(0.013)	0.355***	(0.010)
Mother has diploma	0.336	(0.008)	0.313	(0.013)	0.351**	(0.011)
Mother high school graduate	0.155	(0.006)	0.178	(0.010)	0.141***	(0.008)
Mother Australian	0.759	(0.008)	0.707	(0.012)	0.791***	(0.010)
Additional control variables						
Mother has poor health	0.080	(0.005)	0.099	(0.008)	0.068***	(0.006)
Neighborhood SES	10.08	(0.014)	10.01	(0.023)	10.13***	(0.018)
Single mother	0.123	(0.006)	0.140	(0.009)	0.112**	(0.007)
Father works full time	0.787	(0.007)	0.745	(0.012)	0.814***	(0.009)
Father works part time	0.041	(0.004)	0.044	(0.006)	0.039	(0.004)
Father's weekly income ($ '00s)	7.952	(0.142)	7.757	(0.228)	8.074	(0.181)
Father has poor health	0.080	(0.005)	0.081	(0.008)	0.080	(0.006)
Robustness dependent variables						
MLFP while pregnant	0.600	(0.008)	0.406	(0.013)	0.722***	(0.01)
Needs medication	0.125	(0.006)	0.128	(0.009)	0.123	(0.007)
Child injuries	0.239	(0.011)	0.247	(0.012)	0.234	(0.014)
Sample size	3,179		1,223		1,956	

Notes: Figures are sample means. Standard errors are reported in parentheses. Stars denote significant difference between the sample mean of working (participating) and nonworking mothers.

***Significant at the 1 percent level.

**Significant at the 5 percent level.

an advantage, as parental reports are more likely to be biased and suffer from measurement error. It does appear, however, that teachers keep parent's informed and so the teacher measures reflect objective parental assessments. For example, the survey finds that 80 percent of parents believe their child's teacher does a good job of informing them about their child's progress.

We have teacher assessments for about 65 percent of the children because not all children attend a program with a teacher and some teachers do not complete the postal survey. More specifically, 5 percent of children in the sample did not attend preschool or kindergarten, 2 percent of the parents did not give permission for the

survey organizers to contact the child's teacher, and 28 percent of the children had teachers who did not return a completed survey.[7]

Teachers were asked to think about the skills and competencies of the study child (as described in the next statements), and then to rate each child compared to other children of a similar age over the past few months. The five areas were: social/emotional development (e.g., adaptability, cooperation, responsibility, and self-control); approaches to learning (e.g., attention, observation, organization, and problem-solving); gross motor skills (e.g., running, catching and throwing balls, and strength and balance); fine motor skills (e.g., manual dexterity, using writing and drawing tools); receptive language skills (e.g., understanding, interpreting, and listening). Preschool and/or kindergarten teachers were asked to give one of four possible responses: much less competent than others, less competent than others, as competent as others, and more competent than others.[8] From these responses, we create an ordinal measure of child development that equals the number of developmental areas in which the child is assessed as "less competent" or "much less competent" than other children. The development measure, which is increasing in poor development, takes the values from 0 to 5 with the following frequencies: 63.1, 15.0, 7.5, 6.5, 4.7, and 3.2, and has a mean of 0.84 and a standard deviation of 1.36.

Summary statistics for the development measure, as well as various family characteristics, and all control variables, are presented in Table 1. They are calculated for the whole sample (column 1) and by maternal labor force participation (columns 2–3). The summary statistics indicate that participating mothers systematically differ from nonparticipating mothers along various characteristics. For example, mothers who participate in the labor market are older, have fewer children, and are more highly educated than nonparticipants. In terms of child development, the raw means suggest that children whose mothers participate in the labor force have significantly better development scores (0.715 versus 1.032) than children whose mothers stay at home. The aim of this paper is to determine whether this raw difference in child development by maternal labor force participation remains, once we have controlled for the effects of observable and unobservable characteristics.

II. Using Handedness as an Instrumental Variable

To overcome the potential endogeneity problems between child development and maternal labor force participation, we require a valid instrument. This instrument must be strongly correlated with the child development measure; and uncorrelated with maternal labor force participation, except through child development.

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[7] We examined the possibility of sample selection by regressing the teacher's decision to complete and return the survey on a wide range of child, parental, and household characteristics, and found no evidence that these characteristics are significantly associated with the teacher's decision to provide the assessment. Furthermore, we tested whether a child's handedness significantly influences the probability of having a completed teacher survey, and found that it does not.

[8] Teachers were also asked to evaluate children on their expressive language skills. In our sample, handedness is not significantly related to expressive language development, and, so, we do not use the results from this evaluation. See Johnston et al. (2009) for more details.

The relationship between child handedness and the probability of being assessed as less or much less competent than other children is shown in Figure 1. The figure indicates that both left-handed and mixed-handed children perform much worse in all skill areas. Furthermore, these significant development differences are not diminished when we control for family characteristics (see results in Johnston et al. 2009). Thus, handedness is a strong and significant predictor of child development. The second question is whether handedness, unlike child development, is not, itself, caused by maternal labor supply choices or aspects strongly related to labor supply that are not accounted for in the regressions.

The psychology literature proposes two main theories for the determination of handedness that are consistent with the observed differences in cognitive ability. The predominant theory is that handedness is determined by one gene with two alternate forms (called alleles), one dominant and one recessive, and that right-handed individuals who receive one of each allele have a cognitive advantage over left-handed individuals who receive two recessive alleles (Marian Annett and Margaret Manning 1989). Therefore, under this theory the lower ability of left-handers is "naturally" occurring and is not caused by parents' socioeconomic status, education, health, demographic characteristics, or behavior. It is believed that this genetic link is primarily through the child's mother.

One important implication of the genetic model, however, is that it is possible that mothers of left-handed children are more likely to be left-handed (though the vast majority will be right-handed), implying that if left-handed mothers have different labor market outcomes than right-handed mothers our results could be biased. The current evidence, although not extensive, suggests that left-handed mothers do not have significantly different labor market outcomes. While there is suggestive evidence of a labor market premium for left-handed men compared to right-handed men (suggesting overcompensation of early deficiencies), the evidence for women is weak and inconclusive. In fact, there does not exist any female handedness differential in the United States (Christopher S. Ruebeck, Joseph E. Harrington, and Robert Moffitt 2007), and only weak support of this proposition in Great Britain (Kevin Denny and Vincent O'Sullivan 2007). Furthermore, the bias this link would generate would be in the "opposite direction" (i.e., the link would create a positive correlation between our observed child development and initial wealth), which would mean that the true labor market response of poor child development is even larger than we estimate.

Ideally, we would control for the genetic link by including maternal handedness in our empirical models. Unfortunately, however, information on maternal handedness is not collected in the LSAC. Due to the potential intergenerational correlation in handedness, if mothers of left- and mixed-handed children have a different propensity to work, then our IV strategy could be invalid. We further investigate this possibility in Section IV by estimating placebo regressions that explore whether mothers of left- or mixed-handed children have a different propensity to work than other mothers. We find no evidence of this.

The second theory that might explain child development differences is that a minor proportion of observed left-handedness is the result of a prenatal brain insult which causes a cognitive decline as well as a shift toward left-handedness (Paul Bakan,
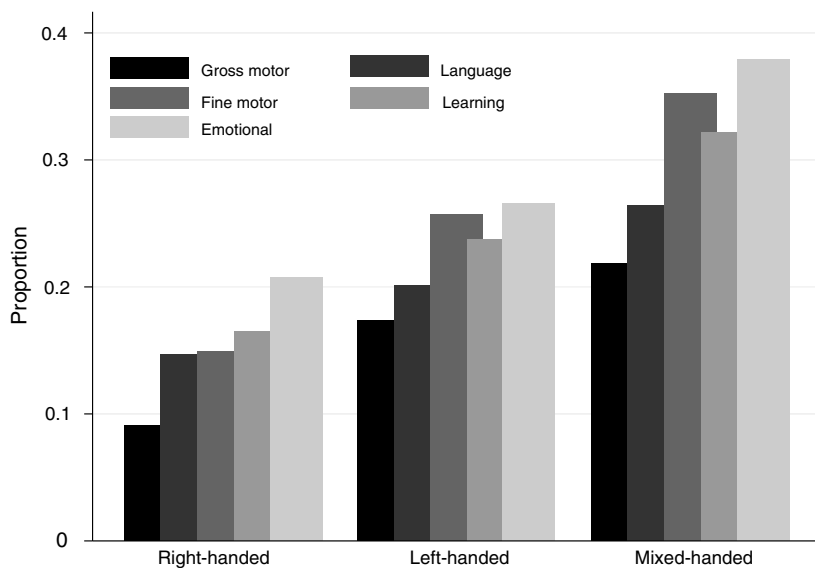
Figure 1. Proportion of Poorly Developed Children by Handedness

Gary Dibb, and Phil Reed 1973; Paul Satz et al. 1985).[9] This is in principle a "valid" source of variation because it is not influenced by labor supply several years later. The slight concern is that there may be reasons for the prenatal stress that still have persistent effects on current labor supply decisions. Therefore, we include variables in all models that are correlated with the incidence of prenatal stress, namely, child's birth weight, child required intensive care after birth, child born premature, child a twin or triplet, and child requires medication at age 4. We also include a measure of whether the mother has poor health in order to control for any potential correlation between prenatal stress and mother's health in subsequent years.

III. Estimation Framework and Results

Estimation is based on a regression model of maternal labor force participation (MLFP). For family i, we assume that MLFP is given by

$$(1) \qquad L_i = \beta_1' \mathbf{X}_i + \alpha_1 cd_i + \varepsilon_{1i},$$

where L_i is a binary variable representing mother i's participation, $\mathbf{X}_i$ is a vector of family characteristics, cd_i is child development, and ε_i is a random error term. The coefficient α_1 is the parameter of primary interest and represents the impact that child development has on MLFP. The $\mathbf{X}_i$ vector includes the child-level characteristics: gender, age, health at birth (birth weight, intensive care birth, premature birth, and multiple birth), current health, and number of older and younger siblings; and the mother-level

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[9] Johnston et al. (2009) perform tests of this theory and find only weak supporting evidence. Instead, they conclude that the genetic model provides a better explanation for the observed ability differences.

characteristics: age, age squared, and dummy variables for highest educational attainment (degree, diploma, high school graduate) and immigration status.

OLS estimates of equation (1) are reported in column 1 of Table 2. The estimates indicate that mothers of poorly developed children are less likely to participate in the labor force. More specifically, increasing the number of skill areas in which the child is less competent by one, reduces maternal participation by 3 percentage points. While the majority of previous studies use child health measures (and, so, are not directly comparable), Powers (2003) shows that having a child who is unable to do age-standard activities reduces wives' labor force participation by 6 percentage points. It appears that the magnitude of our coefficient is reasonably similar in size to previous findings. However, these single-equation estimates may be upward or downward biased, depending on the effect that maternal employment has on child development and on the correlation between omitted variables and child development. For example, if maternal employment has a positive impact on poor child development, then we would expect the OLS estimate of α_1 to be biased upward.

The strong likelihood of endogeneity bias motivates our use of a two-stage least squares estimation approach. The first-stage equation in this approach is

$$(2) \qquad cd_i = \lambda_1' \mathbf{X}_i + \delta_1^l lh_i + \delta_1^m mh_i + v_{1i},$$

where lh_i and mh_i represent child left-handedness and mixed-handedness, respectively. The 2SLS model should capture the causal effect of poor child development for those children whose development is affected by handedness. Importantly, though cd_i is ordinal, 2SLS estimates of α_1 can be interpreted as estimating the average effect of a unit increase in cd_i for those children whose development is affected by handedness (Joshua D. Angrist and Guido W. Imbens 1995).

Before presenting the 2SLS estimates, we present a reduced form analysis of MLFP. We would expect to observe mothers with left- and mixed-handed children to have lower participation, because child development is negatively affected by left- and mixed-handedness. Column 2 of Table 2 presents the relationship between handedness and MLFP. The estimates indicate that mothers with left-handed children are approximately 6 percentage points less likely to participate than mothers with right-handed children, and this result is statistically significant from zero at the 0.05 level. While the estimation results indicate that mothers with mixed-handed children are also less likely to participate, the coefficient is not statistically significant.

The reduced-form effects capture the impact of handedness on MLFP without specifying the pathway for this impact. Alternatively, 2SLS estimation allows us to scale these reduced-form effects into the effects on an increase in our ordinal child development measure. We present the 2SLS first-stage results in column 3 of Table 2. The estimates show that handedness significantly affects child development, with left- and mixed-handed children faring worse than right-handed children. Most importantly, the instruments are jointly significant ($F = 25.5$), indicating that we do not have a weak instruments problem.

TABLE 2—MATERNAL LABOR FORCE PARTICIPATION (MLFP) AND CHILD DEVELOPMENT (CD)

Dependent variable:	Single eqn (OLS) MLFP (1)	Reduced form (OLS) MLFP (2)	2SLS 1st stage CD (3)	2SLS 2nd stage MLFP (4)	IV Probit 2nd stage MLFP (5)
Poor development	−0.030*** (0.006)			−0.107** (0.050)	−0.115** (0.048)
Left-handed		−0.059** (0.027)	0.319*** (0.077)		
Mixed-handed		−0.047 (0.036)	0.635*** (0.104)		
Male	−0.011 (0.017)	−0.026 (0.016)	0.534*** (0.047)	0.032 (0.033)	0.035 (0.034)
Age 5	0.016 (0.021)	0.016 (0.022)	0.004 (0.061)	0.015 (0.022)	0.020 (0.023)
Birth weight	0.011 (0.016)	0.015 (0.016)	−0.158*** (0.046)	−0.002 (0.019)	−0.002 (0.020)
Intensive care birth	0.010 (0.025)	0.009 (0.026)	0.073 (0.073)	0.017 (0.026)	0.018 (0.028)
Premature birth	−0.016 (0.031)	−0.020 (0.031)	0.136 (0.088)	−0.006 (0.032)	−0.004 (0.034)
Multiple birth	−0.057 (0.052)	−0.059 (0.052)	0.100 (0.149)	−0.050 (0.053)	−0.053 (0.059)
Needs medication	−0.008 (0.025)	−0.012 (0.025)	0.161** (0.071)	0.005 (0.027)	0.006 (0.028)
Number of older siblings	−0.061*** (0.009)	−0.061*** (0.009)	0.006 (0.026)	−0.060*** (0.009)	−0.065*** (0.011)
Number of younger siblings	−0.179*** (0.014)	−0.177*** (0.014)	−0.055 (0.040)	−0.183*** (0.014)	−0.192*** (0.017)
Preschool at school	−0.162*** (0.047)	−0.178*** (0.047)	0.493*** (0.135)	−0.125** (0.054)	−0.154** (0.066)
Preschool center	−0.205*** (0.048)	−0.212*** (0.048)	0.179 (0.137)	−0.193*** (0.049)	−0.229*** (0.062)
Preschool at daycare	−0.081 (0.049)	−0.087 (0.049)	0.125 (0.141)	−0.074 (0.050)	−0.097 (0.063)
Mother's age	0.028*** (0.006)	0.029*** (0.006)	−0.044** (0.018)	0.024*** (0.007)	0.035*** (0.011)
Mother's age squared	−0.038*** (0.010)	−0.039*** (0.010)	0.068** (0.028)	−0.032*** (0.011)	−0.048*** (0.016)
Mother has degree	0.234*** (0.024)	0.245*** (0.024)	−0.388*** (0.070)	0.204*** (0.032)	0.198*** (0.036)
Mother has diploma	0.159*** (0.023)	0.166*** (0.023)	−0.218*** (0.066)	0.141*** (0.026)	0.137*** (0.030)
Mother high school graduate	0.083*** (0.027)	0.092*** (0.027)	−0.268*** (0.078)	0.062** (0.031)	0.059 (0.033)
Mother Australian	0.122*** (0.019)	0.124*** (0.019)	−0.087 (0.055)	0.115*** (0.020)	0.124*** (0.024)
Sample size	3,179	3,179	3,179	3,179	3,179

Notes: This table reports OLS (columns 1–2), 2SLS (columns 3–4), and IV probit (column 5) results. The IV probit results are marginal effects, calculated at the mean values of the explanatory variables. The omitted categories are "mother is a high school drop-out" and "day care center without preschool." The F statistic testing the joint significance of the instruments is $F = 25.5$ (column 3). The Sargan over-identification test statistic for the 2SLS model is $\chi^2 = 1.267$, $p = 0.26$ (column 4). The correlation coefficient for the IV probit in column 5 is 0.293 (se = 0.169). Standard errors are reported in parentheses.

    ***Significant at the 1 percent level.

    **Significant at the 5 percent level.

Column 4 of Table 2 presents our main 2SLS second-stage results. We find that increasing the poor child development measure by one, reduces MLFP by 10.7 percentage points, and this result is statistically significant at the 0.05 level. The 2SLS estimate is significantly larger than the single equation OLS estimate. Given that the average rate of maternal labor force participation in the sample is 60 percent, it is clear that mothers react strongly to having a poorly developed young child.

Column 5 of Table 2 reports the results from an IV probit model that better respects the binary nature of MLFP. This model is represented by the following two equations:

$$(3) \qquad\qquad L_i^* = \beta_2' \mathbf{X}_i + \alpha_2 cd_i + \varepsilon_{2i}$$

$$cd_i = \lambda_2' \mathbf{X}_i + \delta_2^l lh_i + \delta_2^m mh_i + v_{2i},$$

where $L_i = 1$ if $L_i^* > 0$, and zero otherwise, and the error terms ε_{2i} and v_{2i} follow a bivariate normal distribution with nonzero correlation. The estimated effect from this model is shown in column 5 and is similar to the values obtained using 2SLS. Interestingly, the 2SLS and IV probit estimates (0.107 and 0.115) of the effect of child development on MLFP are much larger than the corresponding single equation OLS estimate (0.03). The most likely reason for the difference is that maternal employment has a negative impact on child development in our sample.

IV. Instrument Validity and Robustness

A. *Validity*

We assess our identification assumption by computing the Sargan over-identification test statistic for the 2SLS model presented in Table 2. This tests whether left- and mixed-handedness correspond to two separate independent draws from the universe of valid instruments. Rejection of the null hypothesis of this test means either that (one of) the instruments is endogenous, or there is model misspecification. The estimated χ^2 is 1.27 and the *p*-value for this statistic equals 0.26, meaning we cannot reject the null hypothesis that both instruments are valid.

As previously discussed in Section II, handedness is most likely the result of a genetic process and, consequently, is unrelated to the behavior of parents after birth (such as breastfeeding, quality of child care, etc). However, there does exist an intergenerational correlation in handedness, which could imply that mothers of left- and mixed-handed children are somehow different than other mothers. To investigate this possibility, we estimate two placebo regressions. First, we regress MLFP during pregnancy on child handedness and our set of control variables. If mothers of left- or mixed-handed children have a different propensity to work than other mothers, then the handedness variables would be significant. We find that handedness is not significantly related to MLFP during pregnancy (column 1, Table 3). These findings suggest that child left-handedness is not related to some unobserved heterogeneity in the propensity of the mother to work. In contrast, a regression of MLFP during pregnancy on our child development measure in column 2 indicates that mother's

with children who turn out to be poorly developed are significantly less likely to have worked while pregnant. The coefficient on child development is -0.02 and is statistically significant from zero at the 0.01 level. This indicates that there is an endogeneity problem in the naive OLS estimation of equation (1) in that particular types of mothers have children with development problems.

Another potentially complicating factor is that there exists a slight tendency for left-handed individuals to have higher (e.g., immune disease, deafness, asthma) and lower prevalence (e.g., brain tumors) of certain health conditions (for a review of the evidence see P. J. Bryden, J. Bruyn, and P. Fletcher 2005). Though most of the evidence concerns adults, the existence of such a relationship could imply that mother's are reducing their labor force participation in response to their child's poor health, rather than their child's poor development. We investigate this possibility by determining whether left-handed children in our sample have worse health outcomes. Child health is represented using two different measures: an indicator of whether the child currently needs or uses medicine prescribed by a doctor; and the number of times the child has been hurt, injured, or had an accident and needed medical attention from a doctor or hospital. Regression analysis from columns 3 and 4 of Table 3 indicate that handedness is not significantly related to either of the health outcomes. Therefore, it appears that our main results are not biased by a relationship between left-handedness and child health.

B. *Robustness*

In this section, we further test the robustness of our main 2SLS result presented in column 4 of Table 2. First, we investigate whether mixed-handed children are driving the identification because they are in some unobservable way "different" from other children. For example, it is possible that mixed-handed children are developmentally delayed. Although hand preference develops early in life, the rate of development can vary by child. Children who are categorized as mixed-handed may be developmentally delayed in relation to their hand preference and cognitive ability, and this may have little to do with laterality, per se. To investigate this possibility, we drop mixed-handed children from the sample and use only left- versus right-handed children as the instrument. The 2SLS estimated effect from this specification shown in Table 3, column 5 equals -0.18 and is significant at the 0.05 level. Thus, it appears that our results are robust to this particular concern.[10]

Second, we investigate whether including additional control variables affects our findings. More specifically, we estimate a 2SLS model with all the controls used in Table 2 and some additional controls for single mother status, mother and father's health, dummy variables for father's labor force status (works full time, works part time), father's weekly income, and neighborhood socioeconomic status. In this expanded specification, the instruments are, again, significant in the first

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[10] It is also possible that some children are incorrectly classified as mixed-handed if they are handicapped or disabled. We examine this possibility by dropping the ten children from our sample who have a long-term medical condition that is associated with brain damage/injury, or that creates difficulties in gripping things. The estimated effect equals -0.105 ($t = -2.04$) compared to -0.107 ($t = -2.14$) for the full sample.

TABLE 3—ROBUSTNESS TESTS

	Instrument validity				Robustness		
Dependent variable	MLFP while pregnant	MLFP while pregnant	Child needs medication	Child injuries	MLFP	MLFP	MLFP
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Poor development (main)		−0.020*** (0.006)			−0.181** (0.090)	−0.103** (0.050)	
Poor development (alt)							−0.154** (0.076)
Left-handed	−0.028 (0.026)		0.010 (0.019)	0.039 (0.036)			
Mixed-handed	0.014 (0.036)		0.024 (0.026)	0.027 (0.048)			
Sample size	3,179	3,179	3,179	3,179	3,009	3,179	3,179
Estimation method	OLS	OLS	OLS	OLS	2SLS	2SLS	2SLS
Main controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Additional controls	No	No	No	No	No	Yes	No

Notes: Standard errors are reported in parentheses.
   ***Significant at the 1 percent level.
    **Significant at the 5 percent level.

stage ($F = 25.7$), and the estimated child development effect equals -0.103 and is significant at the 0.05 level (column 6, Table 3). Thus, the inclusion of these additional controls has no discernible impact on our main result.

Third, we follow the approach outlined in Angrist and Imbens (1995) that entails looking at which part of the child development distribution is mainly responsible for the IV results.[11] Left-handedness induces a large fraction of the children to be poorly developed in either one or two developmental areas, while it induces a smaller fraction to be poorly developed in three, four, or five areas. Therefore, the children contributing most to our IV estimates are those who have moderate developmental problems, not those who are severely underdeveloped.

Finally, we re-estimate the model using a different measure of child development. The alternative child development measure is constructed by using factor analysis to extract the principal component from the five ordinal teacher evaluations. This measure is then standardized to have a mean of zero and standard deviation of one. The 2SLS estimate using this measure equals -0.154 (column 7, Table 3), suggesting that a one standard deviation decrease in child development significantly decreases MLFP by approximately 15 percentage points. Again, our main result is robust to the alternative measure of child development.

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[11] An important identifying assumption for their approach is that the counterfactual level of child development is always lower for one type of handedness than for the other (their Assumption 2). We are able to perform the one-sided test (a necessary but not sufficient condition) they propose for ordinal data by looking at whether the CDF of each child development problem is nonoverlapping. We find there is no overlap.

V. Conclusion

It has been documented that the proportion of children who have development problems has increased considerably in developed countries in recent decades. In this paper, we provide a contribution to the general literature on child development by estimating the causal effect that poor early child development has on maternal labor force participation. Mothers of poorly developing children may choose to remain at home in order to care for their children, or they may decide to enter the labor force in order to increase the household budget. The aim of this paper has been to establish which one of these two labor market responses empirically dominates.

To address this question, we have analyzed data from a large sample of Australian children aged 4 and 5, combining information from parents as well as from preschool or kindergarten teachers who provide assessments of children's relative competencies over a wide variety of aspects of early child development. Importantly, we have been able to control for the endogeneity problems that arise in such analysis by exploiting exogenous variation in child handedness for identification. We believe that this is the first paper to use such an identification strategy. We have conducted a number of validity and robustness tests of our identification strategy, and have found that mothers react strongly to poor child development by reducing their labor market participation. Moreover, this effect is considerable, with an extra child development problem being estimated to reduce participation by approximately 10 percentage points. To put this in a useful context, the negative effect of two additional units of poor child development on maternal participation would act to cancel out the positive effect of a mother having a university degree (relative to being a high school drop-out). Importantly, this estimate is approximately three times the size as that found when child development is treated as exogenous in the maternal labor force participation model.

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